HE STORY OF SUGAR

GEORGE THOMAS SURFACE

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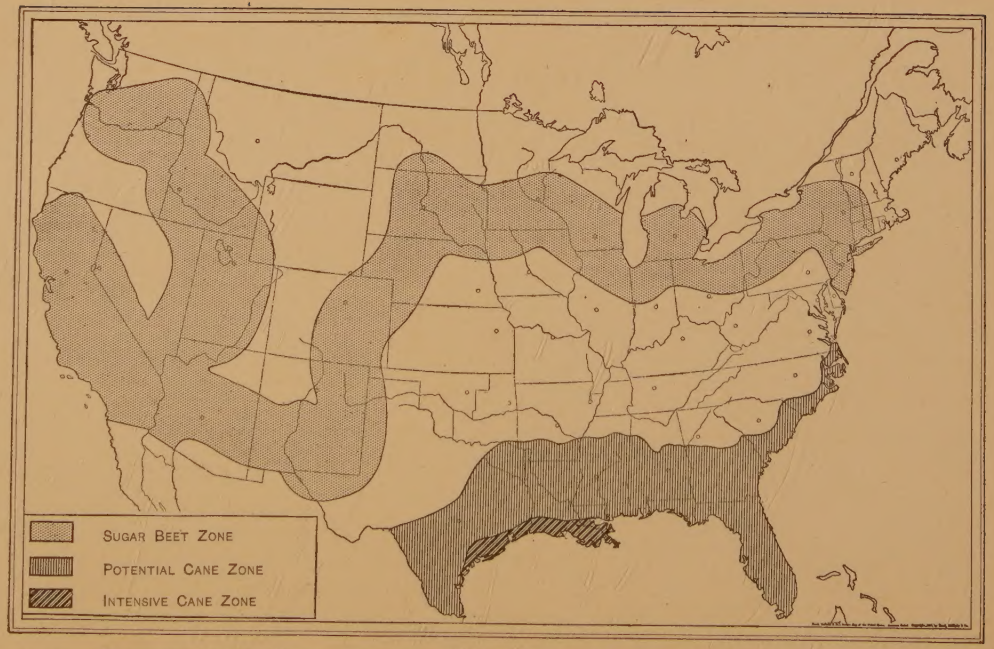
STORY OF SUGAR



DISTRIBUTION OF SUGAR BEET AND SUGAR CANE AREAS IN THE UNITED STATES.

THE STORY OF SUGAR

BY

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PREFACE

EXCEPTING the technical and trade literature, very little has been written on the world's sugar industry, and yet no commodity of commerce has had a more varied, interesting, and significant history. This volume is intended to convey accurate and readable information on the industry in the different periods and stages of its development. Although it is primarily designed for the general reader, the study is replete with facts and economic deductions which will make it a valuable source of reference in any course on industries or commerce.

The exploitation of no other product has so influenced the political history of the western world, and in the United States it holds the unique position of having ushered in an era of corporation development and control unprecedented in the history of the world. We have led the sugar-consuming countries of the earth in the variety of ways in which sugar is used as a staple article of

food, and are only exceeded by Great Britain in the per capita consumption. The story of sugar which follows places due emphasis on the conspicuous position of this country, both past and present, as a producer, consumer, and distributer. Naturally, the beet-sugar industry receives special consideration from the standpoint of future prospects, since this must be regarded as an infant industry in the light of its rapid growth during the past two decades.

I acknowledge with thanks the information and suggestions of the following: The State Departments of Agriculture and the Agricultural Experimental Stations of the cane and beet-growing states; the Editors of the *Louisiana Planter* and the *American Sugar Industry and Beet-Sugar Gazette;* and Professors J. Russell Smith and Walter Sheldon Tower, of the University of Pennsylvania. I am personally indebted to my father, Rev. F. D. Surface, for his valuable and painstaking assistance in proof-reading.

GEORGE THOMAS SURFACE.

Sheffield Scientific School of Yale University,
New Haven, Conn., May, 1910.

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THE STORY OF SUGAR

CHAPTER I

OCCURRENCE IN NATURE

The sugars have a wide occurrence in nature, and constitute important food for both plants and animals. They are manufactured in green plants from carbon dioxide and water, and contain hydrogen and oxygen in the proportion to form water. Some plants, like the onion, utilize sugar during the period of germination, while others—for example, the beet—consume part of the stored-up sugar in maturing the flower into fertile seeds. Most plants store up starch in the seed, which during the period of germination is converted into sugars for available plant food. There is great variation in the method and amount of sugar manufactured by different plants. Those plants having a conspicuous sugar content are designated as sugar-producing plants, in which it is concentrated chiefly in the fruit, seed, root, or sap, depending on the species. Cane sugar (su-

crose) is by far the most abundant of the sugars developed in plants, being the predominant sugar constituent in sugar cane, sorghum, beets, maples, melons, and the various small and orchard fruits. The sugar from the sugar cane, the sugar beet, and the sugar maple are chemically identical as to the chief saccharine constituents, so that technically all of the sugar consumed as a food is *cane sugar;* but by common usage and statistical custom the sugar of commerce is classified as cane, beet, maple, etc.

Sugar cane (*Saccharum officinarum*) was for centuries almost the only source of commercial sugar, but is now being strongly rivaled by the sugar beet. It is a member of the large family of grasses, and may be considered one of the giants of the family, as the stalks frequently attain a height of fifteen feet. The other important members of this family are the bamboo, Indian corn, sorghum, the various cereals, and many forage grasses; all of which contain sugar in greater or less quantity.

Matured sugar cane contains by weight an average of eighteen per cent cane sugar, ten per cent cellulose, seventy per cent water, and one to two per cent mineral matter. The proportions vary with climate, soil, method of cultivation, and the variety selected.

There are many varieties of cane, which vary widely in size, color of stalk, color and length of leaf, color and quantity of sap, sugar content, rapidity of growth, and in the power to endure

Stalk of Sugar Cane Showing Root, Stem, and Leaves.

extremes of temperature and humidity. The roots, as in other grasses, are fibrous, radiate from the lower nodes laterally, and are relatively short, which makes sugar cane easily susceptible to the destruction of storms. The stalk is cylindrical, and consists of numerous joints of varying lengths. The leaves are alternate, linear in type, and from one to three feet long. The leaf clasps the stalk at the node or joint, and immediately under the base of each leaf in the node is a bud incased in a protecting sheath, the external part of which is covered with a plant enamel for protecting this vital part of the plant against extremes of temperature and the ravages of insects. These buds contain a germ capable of propagating an individual plant when the joints are planted. Above each joint is a row of dots or points, which extend around the stalk, and produce temporary roots when the stalk is planted. Botanists long believed the seed of the cane to be sterile, but in the past few decades fertile seeds have been developed in many tropical varieties. The percentage of fertile seeds is so small, however, that reproduction by planting the stalks is general in the cane-growing countries. Some varieties do not produce flowers, and in the United States these are usually preferred, since the crop deteriorates less rapidly in case of delay in harvesting. Cane matures about three months

after flowering, while the sugar beet consumes a part of its sugar content in the process of maturing its seeds. The leaves of cane are shed from the bottom upward, until finally the stalk stands naked except for a few leaves at the upper extremity; and this marks the stage when the crop is ready for harvesting.

Sorghum, or Chinese cane, bears a close resemblance to sugar cane in appearance, and in its cultivation requirements. It differs in the perfection of its flowering and in its capacity for seed development, as a result of which propagation by seed planting is almost universal. It also differs in the duration of its growing period, sorghum maturing in five to six months, whereas cane requires nine to thirteen months. Sorghum is also better adapted to the climatic conditions of the temperate zone, which gives a larger crop and a more utilizable sugar content. It has a limited cultivation throughout the United States north of the Gulf States. The sugar content varies from ten to thirteen per cent, but the presence of a small percentage of starch and dextrin makes difficult the crystallization of the sugar from the juice. For this reason the amount of sugar manufactured from sorghum is insignificant, and the crop is utilized for the manufacture of molasses.

Indian corn, or maize, has been used experiment-

ally in the manufacture of sugar. It flourishes throughout the temperate zone where the moisture and soil conditions are favorable, and where the growing season is not less than five months' duration. Its habitat closely coincides with that of sorghum and sugar beets. The sugar of the sap begins to decrease with the development of the ear, and it is now suggested by some sugar experimenters, that, by preventing the formation of the ear, it may become a profitable commercial source of sugar, since the percentage of sugar can be thus increased to about twelve per cent.

The bamboo is a sugar-producing plant which was utilized by the ancient peoples of Asia, and probably was the first plant from which sugar was extracted. It is not a successful competitor with sugar cane and beets, being lower in sugar and higher in cellulose. The amount of sugar in the bamboo varies widely during the different stages of its growth, as well as in the different species.

For centuries sugar has been manufactured from the different species of palms by the natives of India, Ceylon, Siam, the Malay Peninsula, and the Eastern Archipelago. The wild date palm (*Phœnix sylvestris*) is the only important producer of date sugar, which, though used by the natives of Bengal centuries ago, did not find its way to the London market until 1793. The first shipment

was small (36 hundredweight) and experimental. The total production in Bengal during 1793 was estimated at 10,000 hundredweight. The date palm requires a humid soil and climate, and flourishes best in the vicinity of water. The trees are tapped during the first cold days of autumn (about November 1st), so that the sap is collected in descending. The wild date palm and the nipa palm are richest producers, the juice of which averages ten to twelve per cent sugar. With the maturing of the date much of the sugar of the sap becomes fixed in the fruit. Raw date sugar deteriorates more readily and more rapidly than raw cane sugar, but when refined it is equally stable. The deterioration of the raw product is largely due to the presence of a higher percentage of gluten before refining.

The sap of many trees contains sweets which are not sugars. The most abundant and conspicuous of these is mannite, which occurs in the larch, apple, cherry, lime, different species of ash, eucalyptus, and camel's thorn. Chemically mannite is an alcohol, which by oxidation passes into several sugars. The manna of commerce is obtained exclusively from the ash (*Fraxinus ornus*) by slitting the bark with the point of a knife, through which the sap exudes so slowly as to give time for the evaporation of the water. Manna contains

sixty to ninety per cent of mannite, and in addition glucose, resin, and mucilage. According to the biblical record manna constituted the food of the Israelites in their journey through the wilderness of Arabia. This was probably obtained from the tamarix tree (*Tamarix mannifera*), which exudes manna abundantly as the result of the infesting of a scale insect (*Gossyparia mannipara*). There is also a lichen common on the Arabian deserts, which exudes manna and may have been an additional source.

There are some insects—chiefly aphids—which secrete from a pore in the back a sweet substance resembling in taste the exudations of many of the above-mentioned trees and shrubs.

During the first two centuries of American history the sugar maple (*Acer saccharinum*) was an important source of sugar and molasses, and there is still an annual production of more than 5,000 tons in the states east of the Mississippi River. There are many species of maple in Eastern Asia, Europe, and the United States. The species indigenous to the United States are as follows: sugar, silver, black, red, striped, and mountain maples in the states east of the Mississippi River; and Oregon maple and vine maple in the Rocky Mountains and Pacific Coast States. Of these the sugar and black maples are richest in sugar, and are the only spe-

cies utilized extensively in the production of sugar and sirup. These products are obtained by evaporating the sap to different stages. The trees are tapped at the beginning of the spring thaw. As the sap flow increases the proportion of sugar decreases, which is further lowered by the blooming of the tree, since the flowers of the maple are rich in nectar. The method and distribution of production will be discussed in a later chapter.

All fruits contain two or more sugars, of which cane sugar, fruit sugar, and grape sugar are the most important. Cane sugar has two and one half times the sweetening power of grape sugar and fruit sugar, which are known as invert, or reducing sugars, because of the readiness with which cane sugar is converted into grape sugar and fruit sugar through the action of an acid, heat, or ferment. Grape sugar can be prepared cheaply by boiling cornstarch in dilute sulphuric acid and neutralizing it with lime. Because of its cheapness (about one half the cost of cane sugar) it has been used to adulterate the light-brown varieties of cane sugar, and is used extensively in the manufacture of table sirups, candies, and artificial honey. All soft candies and a large proportion of stick candies and caramels are made chiefly of starch sugar sirups. Fruit sugar is easily assimilated, has more sweetening power than grape sugar but less than

cane sugar, and is less susceptible to fermentation than grape sugar (dextrose).

Of the American fruits, the apple and pineapple are richest in sugar. The pineapple has 13.3 per cent sugar, of which 11.3 per cent is cane sugar. The apple has given as high as 14 per cent sugar in the fresh fruit. Pears give as much as 9 per cent sugar, while peaches seldom contain more than 2 per cent. Of the small fruits, strawberries lead, with an average total sugar content of 11.3 per cent, and raspberries are second, with an average of 7 to 8 per cent. Although cane sugar ferments readily in dilute solutions, it has strong antiseptic properties in concentrated form, as is demonstrated by the stability of dried and preserved fruits.

During the past century the sugar beet has forged its way from an experimental beginning to first place among the sugar-producing plants. When Maggraff began his experiments in 1747 he was only able to extract 1.5 per cent sugar; and fifty years later his pupil Achard, who erected the first beet-sugar factory, was unable to extract more than 3 per cent sugar. The sugar of the beet is sucrose, or cane sugar, and refined beet sugar differs neither chemically nor physically from refined cane sugar. The manufacture of sugar in the beet is effected in the leaves which draw their food sup-

ply from the air and from the roots. The chlorophyll, or green coloring matter of the leaf, is the stimulating agency for the assimilation of carbonic acid in the protoplasmic cells. The carbonic acid is derived from the air, and the water is supplied chiefly through the roots. The sugar is transferred from the leaves through the veins and stems to the root, where it is stored for future use in maturing the seed. The amount of sugar has been steadily increased in the beet by seed selection, improved cultivation, and geographic distribution. When Napoleon started his investigations on the possible domestic sources of sugar, the maximum sugar content of beets was six per cent. Now beets running below twelve per cent in sugar are not considered a profitable source for manufacture, and crops have been harvested in recent years in the arid states which contained as high as twenty-three per cent. The high sugar content in irrigated regions is produced by the maximum sunshine, and the judicious distribution of water during the growing and maturing season. The presence of requisite mineral matter is also of paramount importance, potash being the most important. The potash is not assimilated, but stimulates the transfer of energy, and as a basic mineral causes the condensation of formaldehyde into sugar and starch. The lower the sugar content the higher will be the percentage of ash.

The following mineral elements occur in varying small quantities in the roots and leaves of the beet plant: potassium, sodium, calcium, magnesium, chlorine, phosphorus, and sulphur.

The sugar beet is distinctly a temperate-zone plant, with an approximate limit of 32° to 45° north and south latitude.

Sugar and sirup have been manufactured in the United States in limited quantities from watermelons. The juice is comparatively free of those non-saccharine elements which make the extraction of sugar difficult. The sugar content varies from five to seven per cent, and crystallizes with difficulty. Eight gallons of melon juice yield one gallon of superior sirup. The increased demand for melons since the introduction of refrigerator transportation and storage has foreclosed the possibility of exploiting commercially this source of sugar and sirup.

Sugar is manufactured from raisins in practically all the countries of southern Europe and western Asia. There are two forms of raisin sugar imported into New York, the one from Syria, Asia Minor, and Turkey, and the other from Spain. That from the Levantine countries is said to be consumed by 250,000 Arabic-speaking people in the cities of the Atlantic seaboard, who prize this sirupy sugar very highly as a coffee sweetener.

The Turks add to the delicacy of the sweet by the use of a few drops of rose water. The crystallized raisin sugar is made in Spain, where it constitutes one of the common domestic products of the small farm. Small quantities are imported into the United States by immigrants from the Iberian Peninsula.

The milk of mammals contains four to seven per cent of milk sugar (lactose), which differs but slightly from cane sugar chemically. It is obtained by evaporating the whey, after removing the curd for the manufacture of cheese. Very little is manufactured in this country, since its use is limited to therapeutic purposes. Pure milk sugar is not affected by yeast, but milk is capable of alcoholic fermentation. Mare's milk is used extensively in Russia and in the countries of western Asia for the manufacture of the alcoholic drinks, koumiss, and kefyr.

Honey has been used as a food since prehistoric times. In fact it was the only concentrated table sweet prior to the separation of sugar from sugar-producing plants. It is very rich in carbohydrates, but contains only a small percentage of cane sugar. The most abundant are the invert sugars, fruit sugar and grape sugar. The chemical composition of honey varies more widely than any other natural source of sugars, since it is determined almost

exclusively by the food sources accessible to the bees. Honeys are of two general types, floral and honeydew, and these seldom show the same analysis in different localities. The sugars of honey constitute about eighty per cent by weight and water fifteen to eighteen per cent. The honeydew honeys, which are elaborated from the secretion of insects, usually contain a larger percentage of cane sugar than the honey from flowers.

In the United States fifty per cent of the honey produced is used in the baking and confectionery trade. The value of honey in the manufacture of bakestuffs and candies is determined by its property of imparting a texture and degree of moisture which cannot be produced by other sugars.

CHAPTER II

EARLY HISTORY OF SUGAR

Sugar was first prepared either from sugar cane or the bamboo, both of which belong to the same family. Students of the subject have differed in their conclusions as to where sugar cane was first cultivated, and no definite conclusion has yet been reached as to when sugar was first prepared. Karl Ritter, the great German scientist, is accepted as high authority in his research investigations on ancient industries. He affirms that the cultivation of sugar cane was limited to Bengal until the fifth century A.D., and that it was native to that part of India. About the fifth century it was introduced into the Tigris Valley, near the city Jondisapur, and was soon introduced into the Euphrates Valley. Sugar cane was carried into China at a very early date, and has been cultivated in that empire continuously since its introduction. The Grecian and Roman historians refer to the cultivation of sugar cane in western India. The earliest

historical records seem to indicate that sugar was obtained in India from the bamboo prior to its separation from the sugar cane. Theophrastus refers to the product as "honey which is from bamboos." Paulus Egineta refers to the same commodity as "Indian salt." Seneca makes the observation, "There is found among the Indians a honey contained in the reed"; and Pliny tells us, "Arabia produces sugar, but that of India is more renowned." This saccharine substance, whether it was obtained solely from the bamboo, or from both the bamboo and the sugar cane, was not used as a food for many centuries, but was prized highly as a medicine. This is the origin of the ancient proverb, "Like an apothecary without sugar," which is still used by the Spanish.

There is abundant evidence to prove that by the tenth century sugar was manufactured in the valleys of the Tigris and Euphrates in sufficient quantities to attract the attention of the traders of other countries. It had ceased to be construed as only possessing medicinal properties, and had gradually gained in popularity as a delicious food luxury to be indulged in during special feasts.

Sugar-cane plants were carried from Arabia into Nubia, Ethiopia, and Egypt, and were first introduced into Europe by the Moors in the eighth century. Until the thirteenth century the cultiva-

tion was restricted to Spain, at which time it was introduced into Cyprus and Sicily.

Prior to the introduction of sugar cane into Europe, honey was the most common saccharin in use, and was recognized as the standard of sweetness. Sugar proved to be a sweet of far greater utility because of the ease with which it could be produced, transported, exchanged, and preserved. It was also incomparably better adapted to the art of cooking. The cultivation of sugar cane became an important industry in Sicily by the fifteenth century. It was in this century that the King of Portugal sent cane cuttings from Sicily for planting in the Madeira and Canary Islands. The industry so flourished that Europe, during the succeeding two hundred years, drew her sugar supply chiefly from these islands. From the Canary Islands sugar cane was introduced into Brazil early in the sixteenth century, and about the same time the cultivation began to assume importance in the Island of San Domingo. The intensity with which the industry was exploited in San Domingo may be judged from the fact that in 1518 there were twenty-eight "sucreries" in the island. From San Domingo the cultivation spread successively to Mexico (1520), Guadaloupe (1644), and Martinique (1650). Sugar cane was not introduced into the American colonies until 1751, during which

year the Jesuit Fathers of San Domingo sent to the Jesuits of Louisiana sugar cane for planting, and also sent negroes, who were accustomed to the cultivation of the plant in their native islands. The cane grew luxuriantly, but the growers were unsuccessful in converting it into sugar. After years of continuous effort and repeated failures, the project was abandoned in 1776, and was not resumed until 1791. During this year Don Antonio Mendez succeeded in manufacturing sugar for the first time in Louisiana, and this was easily accomplished by securing the services of a sugar maker from Cuba. In 1794 Etienne Debore was so successful in the manufacture of his crop that several sugar houses were erected in southern Louisiana. The first cane cultivated in North America was the Creole variety, which was followed by the Tahiti variety. Neither of these was adapted to the soil and climate of the Gulf Coast. Early in the nineteenth century the purple or ribbon cane was planted in Georgia, and grew so satisfactorily that, in 1820, John Coiron introduced it into Louisiana. This gave a new impulse to the cultivation of cane in Louisiana, and in reality marks the commercial beginning of the sugar industry in the United States. The purple canes rapidly spread through the State, and proved so well adapted that they have continued in general use.

Between the tenth and twelfth centuries the Venetians conducted a limited sugar trade with India, Egypt, and Syria. During this period sugar cane was also grown on the Island of Sicily. The Venetians controlled the domestic production and were strong rivals in the import trade, which made the city of Venice the leading market center. The merchants of Genoa were associated with those of Venice in the Mediterranean and Asiatic trade, which has a most important bearing on the interest they manifested later in the search for a more direct and less dangerous route to India.

Recent research on the ancient sea laws has made some remarkable revelations as to the statutes and customs regulating the shipment of sugar. According to Pegolotti, there were four ways of preparing sugar for shipment in the Middle Ages. Large loaves were placed in a palm-leaf hat, covered with a palm-leaf covering, and the hat and the palm leaf sewed together securely. This was then wrapped securely in canvas, on which the merchant placed his mark. Loaf sugar could also be placed in barrels, previously lined with the dry leaves of sugar cane to prevent the loss of sugar in transit. The largest size loaves were packed in chests (*cassa*), which were securely wrapped with canvas and cords. The fourth form of shipment was the cube, which were cut from loaves and six-

teen packed in a chest. Freight rates were fixed largely by the ship space required, so that a lower rate was given on sugar in hats than on sugar in chests. As the sugar-producing countries increased, special laws were enacted, applicable to sugar shipments from different countries. If the record of Pegolotti is correct, the sugar merchants of the Middle Ages obtained concessionary freight rates, in that they paid no freight on the wrappings, chests, and barrels, while other people paid for the weight of the merchandise with all its *tara*. Probably no other industry has maintained so persistently a reputation for unjust discrimination and maladministration. The more sanguine advocates of toleration might explain the present deplorable status of the sugar business in the United States as "history repeating itself," but a more reasonable explanation is that it is the depravity of greed continuing.

The Crusades and the Holy Wars were not without significant effect on the sugar trade. The Crusaders from central and western Europe returned with pleasant memories of the wonderful sweet they had found in Syria, Arabia, Palestine, and Egypt. Their long itinerary through Southern Europe had also brought their attention to the channels of trade through which this newly awakened desire could be satisfied. The closing decades of

the fourteenth century brought unwonted activity to the overland and sea trade routes between Europe and Africa, and between Europe and Asia; and sugar was one of the much coveted commodities in the import trade. In 1420 a Venetian invented a new method of refining sugar which seemed to assure Venice of controlling power in its manufacture and distribution. The importance of the discovery is suggested by the fact that he received 100,000 crowns ($120,000) for his invention.

The largest European consumers were the English, French, Spanish, and Portuguese, who were rapidly tiring of the extortionate prices demanded by the Venice brokers. The price on the London market in 1482 was $275 per hundredweight, which was almost double the price of a century earlier. Stimulating forces were at work from entirely different motives, which were destined not only to change the sugar centers, but to revolutionize the world's trade. The increased Asiatic trade of the Mediterranean merchants developed more serious obstacles along the trade routes. Not only were robberies frequent and destructive, but the Mohammedans exacted heavy tolls for the privilege of passing through their territory. All this was used as a basis and excuse for raising the price on all imports, which in turn fired the purchasers with the desire to eliminate

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the middlemen by trading direct with India and the Red Sea country, and by producing a greater variety of products at home. Following out the latter idea, the Portuguese had already (1422) introduced sugar cane in the Madeira Islands, where it grew so successfully that its cultivation was extended persistently southward, and by 1472 it had been carried along the western coast of Africa as far south as St. Thomas Island, on the equator. Sugar-cane cultivation was now passing through its experimental stages in the islands of the western Atlantic, and Venice began to lose and London to gain control of the western European trade. By the close of the fifteenth century the price of sugar on the London market was $53 per hundredweight, as compared with $275 per hundredweight in 1482. For many reasons the last decade of the fifteenth century marked an epochal period in the sugar industry. The Genoese, Spanish, and Portuguese, in their determination to find a shorter and less hostile route to India and Cathay (China), had discovered the West Indies, and stumbled on a new world. From this new world, to which they were soon to carry sugar cane, they brought the bean of the cocoa tree, from which a much-relished drink was made by the addition of sugar. Its use spread with phenomenal rapidity throughout the Iberian Peninsula, but be-

came especially popular in Spain, where it continues to be used more extensively than elsewhere. To meet the demand, the Spanish began a vigorous exploitation of both the cocoa and sugar industry in the West Indies early in the sixteenth century, while the Portuguese continued to foster the cultivation of sugar cane in the Madeira and Canary Islands. Sugar cane was introduced into Hayti in 1515, which marked the beginning of the industry in the West India group. The Spanish Government levied a heavy import tax, and offered a liberal bounty to all colonists of the island who would erect sugar mills.

Spain and Portugal dominated the sugar industry of Europe during the sixteenth century, but Portugal led in extensions, improvements, and transportation. Her monopoly of the sugar-carrying trade was backed both by her large raw sugar production and by her naval supremacy. Lisbon now became the great sugar-receiving port of Europe, and in consequence flourished. Egypt was taken by the Turks in 1518, which closed to Western Europe the Eastern sources of sugar through the Mediterranean trade routes. This had a far-reaching effect on its exploitation in the islands of the Atlantic. Early in the sixteenth century Antwerp became an important sugar-refining center. This development Portugal welcomed, as it was

near the center of her field of trade—England, Scotland, Denmark, Norway, Sweden, Germany, and Poland. The English attempted sugar refining at London as early as 1544, but were unable to manufacture it so as to compete with the Antwerp refiners. In 1585 Antwerp was taken by the Duke of Parma, and the English were then forced to develop the sugar-refining industry. Following 1585, London became the important refining center of sugar for the European trade.

Diego Velasquez conquered the island of Cuba in 1511–12, and many colonists came to Cuba from Hayti. Spain had the chance of developing an important sugar industry in the West Indies in the sixteenth century, but the Government at this time was gold mad, and discouraged agricultural production in favor of mining. The first sugar mill was erected in Cuba in 1547, but the industry made little progress in the sixteenth century for lack of suitable laborers. A French trading company made a special contract, in 1701, with the Spanish Government for conducting trade between France, Spain, the West Indies, and America, to the value of the negroes sold to the Spanish colonists in the West Indies, and to the North American colonists. During the previous century the Spanish had enslaved the native Indians, but they were neither suited to mining nor to agriculture.

Although the French were chiefly interested in stimulating tobacco cultivation, sugar cane increased steadily with the influx of colonists and the importation of African slaves.

The Dutch possession of Brazil from 1624 to 1654 had given them an important position in the sugar trade. In fact, they were so outbidding England for the West Indian and colonial commerce, that the English resorted to the vigorous policy of the Navigation Acts, restricting the shipment of "enumerated articles to England, Ireland, or some other of his Majesty's plantations; in English, Irish or plantation-built ships, owned by Englishmen, and whereof the Master and three-fourths of the Mariners at least are English." Sugar was the first of the enumerated articles. By the close of the seventeenth century the English had severely crippled the Dutch carrying trade, which, coupled with the establishment and improvement of refining methods at London, enabled the English to control the sugar market, notwithstanding the slight attention they had given to extending the cultivation of sugar in the colonies. The English consumption of sugar also rapidly increased during the latter half of the seventeenth century. Chocolate drinking had already been introduced from Spain, but coffee, introduced in 1650, was destined to grow in favor more rapidly, because

of its being cheaper and more easily prepared. The demand for sugar increased proportionately.

The dawn of the eighteenth century found the English, French, Dutch, and Portuguese struggling for the European sugar trade. England was stimulating production, particularly in Jamaica and the Barbadoes, but lost ground in her foreign trade through the heavy duties imposed by James II. The greatest activity in cultivation was in progress in the French West Indies, and the English policy played to France's favor both in production and distribution. The Dutch traders continued to purchase clandestinely much sugar from the English colonists in the West Indies, which had a salient influence in keeping the price of sugar down in the countries of Europe.

The introduction of sugar cane into the Barbadoes Islands in 1641 gave the first impulse to the slave traffic in the British West Indies. In 1662 the "Company of Royal Adventurers Trading to Africa" was chartered and obligated itself to deliver 3,000 slaves annually to the British West Indies. The West Indian sugar trade with the continental colonies of North America began to assume importance about the middle of the seventeenth century. Inseparably associated with it was the exportation of rum, molasses, and tobacco, and the importation of lumber, horses, and fish. Many

cargoes of sugar, rum, and tobacco were reshipped from the mainland to England. Large consignments of rum were shipped to New England, where it was sold to the Indians for furs, which constituted one of the most important colonial exports from the northern colonies. Rum was at the same time the West Indian export most in demand in the African trade, where it was exchanged for slaves, which were demanded by the sugar planters for increasing the sugar production. The English, French, and the Portuguese were actively engaged in the African slave trade. The West India Islands constituted the center of the intercolonial trade during the eighteenth century. All the economic and physical conditions combined to make it so. Sugar and rum were the largest exports, with tobacco second in importance. These commodities were exchangeable for slaves from Africa, manufactures from Europe, and lumber, fish, and live stock from the continental colonies of America. Europe offered a ready market for sugar, molasses, and tobacco; and the American colonists were heavy purchasers of sugar, molasses, rum, and slaves. The colonies were large exporters to Europe of tobacco, lumber, and furs, where a cargo suitable for the African slave trade could easily be obtained. Whether a ship, therefore, started from Europe, America, or Africa, it was almost impos-

sible for it to have to go in ballast any part of this triangular journey.

The first decades of the nineteenth century were epochal in the changes and readjustments in progress in the sugar industry. The San Domingo negro insurrection was very destructive to the sugar plantations of that island, and Spain had taken advantage of this opportunity to develop the sugar industry in Cuba and Porto Rico. The abolition of the slave trade by England depressed the sugar industry in the British West Indies, and correspondingly enlivened the slave trade and sugar cultivation in Cuba and Porto Rico. In 1800 Havana exported 20,000 tons of sugar, while the export in 1820 was 50,000 tons. As the time approached for the emancipation of all slaves in the British colonies (1833) the sugar cultivation gravitated to the Spanish, Portuguese, and French possessions. In 1828 slave labor was producing more than half of the world's sugar, the leading producing countries which utilized slaves being Cuba and Porto Rico, 65,000 tons; Brazil, 28,000 tons; French colonies, 50,000 tons; Dutch Guiana, 10,000 tons; and Louisiana, 20,000 tons. The beet-sugar industry was at this time growing in importance in Europe, and received an added impetus through the world-wide emancipation of slaves witnessed by the succeeding decades.

CHAPTER III

SUGAR AS A FOOD

Sugars and starches constitute the large class of foods called carbohydrates, which being entirely free of nitrogen are often designated as the non-nitrogenous foodstuffs. They contain carbon in connection with hydrogen and oxygen, and are easily converted by oxidation into fats. The ease of this process makes it an important foodstuff for the generation of heat and the maintenance of physical strength. Cane sugar has a heat or energy producing value as great as lean meat, which is a typical proteid or nitrogenous foodstuff.

Sugars are divided chemically into two classes, single (monosaccharid) and double (disaccharid) sugars. Grape sugar (*dextrose*, $C_6H_{12}O_6$) and fruit sugar (*levulose*, $C_6H_{12}O_6$) are the most common monosaccharids; and cane sugar (*sucrose*, $C_{12}H_{22}O_{11}$), milk sugar (*lactose*, $C_{12}H_{22}O_{11}.H_2O$), and malt sugar (*maltose*, $C_{12}H_{22}O_{11}.H_2O$) are the

most common of the disaccharids. Attention is called to these two classes of sugars for the reason that cane sugar, a disaccharid, must be converted into a monosaccharid before it can be assimilated in the body for the formation of organic tissue and the production of bodily heat and energy. The change is effected either during or immediately preceding absorption. It is of interest to note that practically none of the sugars absorbed enter the circulation through the lymphatic system, but are conveyed into the portal vein, through which they are carried to the liver. Sugar is an essential food for the blood, but to prevent the assimilation of an excess is equally essential. "The liver serves as an effective regulator, maintaining in spite of all fluctuations in the supply and demand, a definite percentage of sugar such as is best adapted to keep the tissue of the body in a normal and healthy condition." (Chittenden.)

Sugars being demanded for a balanced ration, nature has provided for her needs both by a diversified supply and by giving to the higher animals a sensory desire for sweets. Sweet is, therefore, one of the natural tastes, the other fundamental ones being acid, salt, and bitter. This sensory desire is not only present in man, but in many of the lower animals. The bear and the fox, in their ravages on the wild honey of the forest and field,

probably experience a sensory satisfaction resembling that of the hungry child who partakes of sweets from mother's cupboard. It can scarcely be argued that the bee performs an irksome task while it extracts sweets from the choicest flowers and fruits.

A noted physician made the comment recently that sweetness is to the taste what beauty is to the eye, and that Nature's approval is stamped by the fact that sugar is the most universal flavor in foodstuffs, more than one half of foods having a sweet or sweetish taste, as compared with one third which taste salty and about one tenth bitter or sour.

Prior to the separation of sugar from sugar-producing plants, it was consumed in varying quantities in the fruits, roots, barks, and seeds. Men got along for ages with this limited supply, since the starch foods were consumed in large quantities, which, through the processes of digestion, are converted in part into sugars. The utilization of sugar plants thus permits cane and beet fields to render a service long performed by the fields that yielded potatoes, grains, and other starch foods, all of which are less appetizing than the universally appreciated sugar.

The sugars from cane, beets, and the sugar tree are identical chemically, but have been so distinct

in the economic and commercial development of the industry as to justify separate treatment in the Story of Sugar.

During the seventeenth and eighteenth centuries, when the world's sugar supply was so limited, and the transportation facilities so inferior as to make it difficult to obtain the commodity, large quantities of maple sugar were manufactured from the natural sugar-tree orchards so generously distributed over the eastern part of the United States. The demand for sweets was also in part met by the manufacture of molasses from sorghum, which is as naturally adapted to the conditions of the northern half of the United States as is sugar cane to the southern half. With the clearing of the forests and the lowering of the price of sugar from cane and beets, the maple-sugar industry has steadily declined. Since maple sirup has grown in favor and increased proportionately in price, the sap of the sugar tree, where utilized, is almost universally converted into the sirup.

Much has been said of the disastrous results from the excessive use of sugar as a food. It was formerly thought that most of the organic diseases of the liver and kidneys were either directly or indirectly attributable to the heavy consumption of sweets. In the light of modern physiological and pathological research into the relative effects

of the different foods consumed, it seems conclusive that the excessive use of sugar produces no organic impairment except through indigestion, since the portal circulation will not absorb a larger amount of sugar than is required to meet the normal demands for nutrition. Not only will an excess result in serious forms of indigestion, but will likely result in an insufficient consumption of the proteid foods. A balanced ration requires the consumption of both sugars and proteids, and if the investigations of the Minnesota Experimental Station be correct, the nitrogen retention of the proteid food is increased twenty-five per cent when consumed with sugar. It is impossible to say what constitutes an excess of sugar, since what would be an excess for one person would not be for another. The amount of sugar demanded for normal and healthy nutrition depends upon the amount of starchy foods consumed, the habits and physical condition of the consumer, and the demands upon the body through external conditions, such as climate, season, labor, etc.

The content and adaptation of representative foodstuffs for the purposes of nutrition may be judged from the following table:

TABLE I

Composition of Common Foods

Names of Food.	Proteid.	Starch and Sugar (Carbohydrate).	Water.	Mineral Matter.	Fat.
Dried corned beef	39.2	0.0	44.8	11.2	5.4
Dried prunes (edible portion)	2.1	[1]73.2	22.3	2.3	0.0
Dried peas	24.6	62.0	9.5	2.9	1.0
Roast turkey	27.8	0.0	52.0	1.2	18.4
Corn meal	8.4	74.0	11.6	1.3	4.7
Butter	1.0	0.0	11.0	3.0	85.0

[1] Chiefly sugar.

Notwithstanding the rapid increase in the world's production of sugar during the past three decades, the United States has steadily increased her percentage of the total consumption throughout this period. The world's sugar production aggregated 17,000,000,000 pounds in 1887, as compared with 32,000,000,000 pounds in 1907. The United States consumed 18.1 per cent of the total in 1907. Our per capita consumption in 1850 was only 21 pounds, but increased to 53 pounds in 1887, and to 83 pounds in 1908. We now represent the largest consumers of sugar among the nations of the earth, excepting England and Australia, whose consumption in 1907 was respectively 93.5 pounds (England) and 100 pounds (Australia):

TABLE II

EUROPEAN PER CAPITA CONSUMPTION IN 1907

	Pounds		Pounds
Germany	40.92	Spain	11.37
Austria	24.32	Portugal and Madeira	15.51
France	36.05	England	93.50
Russia	20.55	Bulgaria	7.98
Holland	41.40	Greece	10.16
Belgium	29.70	Servia	6.92
Denmark	73.68	Turkey	11.73
Sweden and Norway	47.88	Switzerland	55.22
Italy	7.63		
Roumania	7.83	All Europe	31.61

The great variation in the amount of sugar consumed in the different countries is attributable to many factors, the most important of which are: the average prosperity of the people, the geographical situation with reference to sugar production and sugar markets, the price of sugar, the native foodstuffs in most common use, and the traditions of the people with reference to popular foods.

The increased cost of many foodstuffs has unquestionably increased the sugar consumption. There has been a phenomenal increase in the cost of meats, dairy products, poultry products, and flour. While 1909 was conspicuous for the rise in the price of these important foods, the average price of sugar was somewhat below the price in 1908. This condition is naturally leading the people into the preparation of a greater variety of

dishes in which sugar is an important constituent. Such a necessity comes as a bane to the poor who do heavy manual labor, and who must substitute starch and sugar foods for proteids and fats because of the prohibitory prices on meats and butter.

The amount of sugar consumed in any country fluctuates quite appreciably with the financial condition of the country. In times of great financial depression sugar becomes a luxury to the poorer classes, and they refrain from buying it in favor of cheaper starch foods. This statement is verified by the sugar statistics during the decade 1890–1900. This was a period of protracted and general financial depression in the United States. In 1891 the per capita sugar consumption in the United States was 60.7 pounds, while in 1899 the consumption was 61.8 pounds. In other words, there was very slight increase in the average consumption of sugar during this decade; while from 1899 to 1909 the per capita consumption increased from 61.8 pounds to 83 pounds. The latter period is recognized as one of unprecedented financial prosperity, the proof of which is clearly written in the rapid and general increase in the use of sugar as a food. In addition to the general prosperity of the past decade there has been a decline in the price of sugar which was also conducive to an increased

consumption. The average price of refined granulated sugar in 1890 was 6.27 cents per pound, as compared with an average price of 4.65 cents in 1909. In conformity with the facts, it should also be borne in mind that a part of the increase in the use of sugar in the past decade is attributable to the rapid development of canneries and confectioneries.

An important part of the world's sugar production is consumed in the use of cocoa, chocolate, tea, and coffee; and in the manufacture of wines, rum, and other spirituous drinks. Since the use of all of these beverages and drinks is increasing throughout the world, this will proportionately increase the consumption of sugar in the future. The introduction of coffee into Europe in 1650 gave a new stimulus to the European sugar market during the latter decades of the seventeeth century.

Much has been written as to the comparative qualities of beet and cane sugar, both as a food and as adapted to the culinary art. The United States Department of Agriculture has made extensive experiments during the past two years to determine definitely whether there be any essential difference between these two sugars. The decision of the experts is that there is no essential difference. The claim had been made in certain parts of the country that beet sugar is not so efficient in its pre-

serving qualities when used in the manufacture of jellies, preserves, and canned fruits. The tests of the Government extended not only to these preparations but to a wide variety of cooked foods, so that they are sufficiently representative to be accepted as conclusive.

The consumption of sugar as contained in honey is also increasing rapidly in the United States. The bee culture business is being placed on a more scientific and profitable basis, and, whereas honey was formerly consumed almost exclusively in the country, it is now becoming a popular commodity on the city market. The present honey consumption of the United States is estimated at $20,000,000 per year. To meet the demand we are importing 2,500,000 pounds annually, one half of which comes from Cuba and one fourth from Mexico.

The consumption of sirups and molasses continues to increase, but is not increasing in proportion to the increase in population, which means that they are becoming of relatively less importance as national foods. The consumption is naturally heaviest in the cane districts of the South, because of the cheapness of the article as compared with other foodstuffs. In the cane belt the cheaper grades of molasses are beginning to be used extensively as a stock food, and very satisfactory results have been obtained, which would indicate that this

utilization will be much extended in the future. Sugar by-products as a stock food will be further considered in a subsequent chapter.

Refined sugar is subject to very little deterioration, since it is immune to insect enemies and is not subject to fermentation. This is not true, however, of the raw sugars, for which reason great precaution should be exercised in the consumption of sugar before it is refined. As a matter of fact so little unrefined sugar is consumed that it scarcely figures in the retail trade.

It is necessary to prepare sugar in a variety of forms to satisfy the demands of the trade in the different countries of the earth. The most common classes of refined sugar demanded by the trade of this country are bar, cube, tablet, crystallized, coarse granular, medium granular, fine granular, and the pulverized grades. The domestic use of the brown or porous sugars is steadily declining in favor of the granular grades. The brown sugars on the market are not raw, but are taken at intermediate stages in the process of refining.

CHAPTER IV

CONTROLLING FACTORS IN THE PRODUCTION OF SUGAR CANE

Sugar cane is a native of the tropics, and has yielded but little to the coaxing of man to become adapted to the climatic conditions of the Temperate Zone. It has, however, a wide distribution in the tropical and subtropical zones, having been grown as far north as latitude 32° in Spain, and as far south as latitude 37° in New Zealand. An average annual temperature of 75° F., and a seven to nine months' growing season of warm days and nights afford the most favorable temperature conditions. It is a crop which requires a large amount of sunshine and a bountiful supply of moisture. This combination cannot be ideally realized except by irrigation, and so we find that the largest yields of cane have been obtained in regions susceptible to irrigation. It is estimated that during the growing season the soil should contain twenty-five per cent moisture, which will, under normal tropical conditions, be supplied by an annual rain-

fall of 50 to 65 inches. The distribution of the rainfall is as important as the aggregate precipitation, the most desirable distribution being a moderate winter rainfall, a generous supply during the growing season, alternating with periods of clear skies and hot sunshine, and a comparatively dry season for maturing and harvesting. At least two thirds of the total precipitation should come in the growing season. One inch of rainfall on one acre amounts to 27,154 gallons, or 113 tons. An acre of cane, yielding a 45-ton crop, is estimated to have evaporated through the leaves 6,400 tons of water, which is equivalent to a rainfall of 56 inches. In the cane belt of the United States the rainfall is seldom less than 50 inches. The growing season—April, May, June, July—has an average of more than half of the total rainfall, while October, November, and December are the driest months of the year. The growth of the cane crop is so rapid that it requires a continuous and generous utilization of plant foods. An excess of moisture during the growing season will, therefore, be disastrous, as it excludes that admixture of air which makes possible the rapid assimilation of plant foods. A rainy season during the maturing or ripening season lowers the sugar content, makes it difficult to separate, and the harvesting of the crop is almost impossible on account of mud. If the rain is

accompanied by wind the effects are still more disastrous, as cane is not deeply rooted, in consequence of which it is easily blown down, and the stalk has the power of throwing out roots at each joint when brought in contact with the earth. An additional loss is from the breaking of the stalks at the joints, where fermentation soon begins.

The soil adaptation is of paramount importance. Neither heavy clay soils nor loose, sandy soils are best adapted to the cultivation of sugar cane, since the clay soil does not admit sufficient aëration for the rapid assimilation of plant food, and the sandy soil is not only insufficiently retentive of moisture, but the cane rooting in it is too weak to support the weight of the stalk. The fertile loams are, therefore, best adapted to the needs of the crop. The most productive loams are those rich in humus or decayed vegetable matter, those derived from alluvial depositions, and from the decomposition of volcanic, coral, or crystalline rocks. The decayed vegetable matter has the effect of disintegrating the soil more perfectly through the agency of its organic acids, and of supplying an abundance of nitrogenous plant foods so necessary for the growth of the crop. The other plant foods most essential are potash, phosphoric acid, and lime. Tropical soils of alluvial origin are likely to contain all the necessary plant foods, but continued

cultivation will ultimately exhaust the most fertile soils of humus and potash below the quantity required. When the soils become exhausted they not only give an inadequate yield through an insufficient supply of plant food, but become hard and impenetrable, which makes cultivation difficult. Some safeguard measures must, in consequence, be adopted in the sugar-producing countries to prevent exhaustion. The most effective and the most economical is a wise rotation of crops and thorough cultivation. Only within recent years have cane growers begun to realize the importance of restoring fertility to the soil by this method. The clovers, peas, and beans are the most important in the rotation, as they increase the available nitrogen, and when plowed under restore to the soil humus, which has become deficient through continued cropping in cane or cereals. The most popular succession where rotation is practiced is: first year, cane from planting; second year, cane from stubble (rattoon crop); and third year, beans, peas, or lucerne. Frequently corn is planted the third year for the harvest crop, with beans, peas, or lucerne sowed at the last plowing as a cover crop, to be plowed under after the corn is harvested.

It is obvious from what has been said that satisfactory results cannot be expected on land which is not well drained. Good vertical drainage by per-

colation is preferable to lateral drainage, but the physical condition and the configuration of large areas of fertile lands adapted to sugar cane make either under-drainage or open-ditch drainage necessary. The reason that cane grows so luxuriantly on many of the tropical islands is the conjunction of an abundance of moisture, fertile soil, and adequate natural drainage.

When the cultivation of cane began to spread from Asia to other continents the idea prevailed that careful cultivation was not necessary. This deduction was natural, since it propagated itself year after year in some of the most fertile and favorably situated valleys of Asia. Even now there are a few small areas in Porto Rico which have yielded fair crops of cane for twenty years without planting, and under the most inferior cultivation. Too strong a faith has been and is now placed in the persistence of the soil fertility, and in the tolerance of the cane crop.

The labor expended in thoroughly preparing the soil for planting proves an economical investment throughout the season, since it gives the crop a healthful start, and kills out weeds, which will go far toward tiding the crop over wet periods so likely to occur in the spring months. The plowing should be deep, and the soil reduced by harrowing, dragging, and rolling, to a pulverulent condition.

Planting in the United States is practiced both in the autumn and spring, but the best results are believed to be obtained by the autumn planting. On large plantations it begins in September, and is continued until the harvesting season of November and December. Following the harvesting season a part or all of the harvested area will be planted as soon as the weather and soil conditions permit. Autumn planting makes possible an earlier cultivation in the spring, and thereby extends the growing season in the months when the rainfall is heaviest. Great care must be exercised in autumn planting to prevent "wet rot" from imperfect drainage, and "dry rot" through too rapid evaporation of the moisture from the planted stalks. The latter is likely to occur if the land is rough, cloddy, or rocky. When the planting is deferred to spring, the cane stalks to be used in propagating the next crop must be protected against freezing, air exposure, and water soaking. This is done by piling the cane in furrows, which are covered in turn with dirt taken from the sides; or by standing the cane on the butts in conical piles, and covering with dirt. Different parts of the stalk are utilized for propagation, and in this country there seems to be no material difference in the results from the joints of the top and bottom. Frequently the stubble

is planted as rapidly as the cane is cut. The furrows for receiving the cane cuttings are made with an ordinary two-horse turn plow, or with cultivators made for the purpose. The rows are from three to six feet in width, but the close planting has given more satisfactory results in Louisiana. If the rows are three feet apart and the stalks are planted longitudinally, it requires about 4,000 pounds of cane to the acre.

During the first of the growing season the battle is on between the cane and the weeds, and the victory will depend upon the character of the cultivation. The kind of soil required for a profitable cane crop is ideally adapted to the most rapid growth of weeds. The same is true as to conditions of temperature and moisture. The disc cultivators have now an extensive use. They are so set as to throw the soil to the cane row, which covers the weeds in the row, gives the cane a deeper rooting, facilitates drainage, and preserves the stubble if to be used for propagating the next crop. Cane should receive its last cultivation early in July. Following the lay-by the crop makes rapid growth if the season is favorable. The length of the growing season is determined by the climatic conditions, the time of planting, the variety of cane, and the amount of space allotted to each parent stalk.

Cane, like all the grasses, branches by producing suckers at the crown of the root. This process is known as *tillering*, and where a maximum tillering is desired wide planting must be practiced. Some varieties possess a greater tillering tendency than others, and the greater the number of suckers the longer the season required for maturing the crop. As many as one hundred stalks have been produced by one joint of cane containing three eyes, planted in a space six feet square. The wider the planting, the greater will be the number of suckers, but the suckers are less rich in sugar and smaller in size than stalks from original sprouts, so that the repression of suckering, or tillering, is desirable in the propagating stock. This is most successfully effected by close planting and by close cultivating. The cultivations during May and June should be at frequent intervals and shallow so as to produce that condition of tilth so favorable to thorough aëration, moisture conservation, rapid nitrification, and well-balanced assimilation of plant foods.

August and September are the important maturing months, during which the crop receives no cultivation. During this period the canals used for conveying the nutrition-charged waters from the roots to the leaves become less active, and the sieve tubes, for conveying nutrition from the

leaves downward to the stalk, become more active. A dry season is favorable during the last stages of maturing, as a part of the water contained in the plant is consumed to meet the deficiency from soil moisture, which leaves the sap correspondingly richer in sugar content. As the stalks mature they

Cutting Cane.

shed their leaves from the bottom upward, which is due to the fact that during the maturing, or sugar-fixing stage, the water canals connecting the stalks and leaves are closed so as to divert the plant food from the leaf to the stalk. The shedding of the leaves is heralded by a gradual change in the color

of the joints from a green to some shade of red, differing in different varieties. The cane in the Gulf States is not ready for cutting for four to six weeks following the beginning of the change in color. Although harvesting begins in October on account of the large crops and apprehension of unfavorable weather, the cane is not in the best condition until November. The cane is cut by hand, no successful harvesting machine having yet been invented. This makes a heavy demand for labor during the cutting season, as a good cutter can average no more than three tons per day. When the crop is unusually large or late, the cane is frequently cut and piled in rows for protection against frost and freezing. Freezing does not materially damage the quality or quantity of sugar if it is milled before thawing, but to freeze and thaw is very destructive to the sugar, and fermentation sets up immediately. Cane juice contains about seventy per cent of water, and in freezing the pressure of expansion is sufficient to break the cell walls, which causes the intermingling of the vegetable and mineral contents.

Rats are very destructive to growing sugar cane, since wherever they gnaw the stalk fermentation occurs. White ants are great enemies in the tropics where rattoon crops are extensively cultivated, but have caused little loss in the United States.

The most serious insect enemies in this country are the "sugar-cane borer" (*Diatræa saccharalis*), the "Southern grass worm" (of the order *Lepidoptera*), and the "sugar-cane beetle" (*Ligyrus rugiceps*). To avoid the ravages of the borer the best results have been obtained by burning the tops, thus destroying most of the hibernating young. It has few natural enemies. The ground beetles in both the larval and adult stages feed on the grass worms, which keeps them fairly in subjection.

Many varieties of cane from all parts of the cane-growing world have been introduced into the United States experimentally, but none have been found of sufficient adaptability and superiority to supplant the ribbon or striped cane introduced into Georgia and Louisiana in the early part of the nineteenth century. The striped canes have a tendency to change to the violet or purple variety, particularly in the northern portion of our cane belt. As evidence that it is a degenerative form of the striped cane, it is harder, has more fiber, more solids not sugar, greater average reproductive power, and more resistant to changes of temperature.

The margin of risk to the cane grower is much smaller than it would be if cane were propagated by seed, and susceptible to great variation from

local differences or changes of environment. This margin is not so small, however, as it was once believed to be, when ten to twenty-five crops were produced from one planting. It is now known that each succeeding rattoon (propagated from stubble) crop shows a deterioration under its predecessor.

The greatest problem which faces the cane and beet growers of this country is the labor supply, since the cost of production to the grower depends chiefly upon the efficiency and cost of the laborers. Both crops require much hand labor, and both demand a disproportional amount of labor during the planting and harvesting seasons. Because of farm wages being higher in the United States than in any other sugar-producing country, the conditions of competition stand at high tension, and few agricultural crops are so vitally dependent upon minor fluctuations in the cost of production as fixed by the cost of labor. The competition is both internal and external, and of a complicated type, since it involves specific competition between cane and beet sugar under varying conditions of production in the continental United States, in the noncontiguous territory, and in foreign countries; and a general competition between domestic and foreign production. Although the labor scale in the beet-producing zone of the United States is higher

than in the cane belt the relative cost of producing the two crops is about the same. The average sugar-cane production is 16 tons per acre, which sells at an average price of $3.50 per ton; while the average production of beets is 8 to 10 tons per acre, and the average factory price $4.75 to $5.50 per ton. The losses incident to cane cultivation are greater, since more than three fourths of our total beet crop is produced in the arid and semi-arid states by irrigation. The beet crop is also more susceptible to machine cultivation, so that the domestic beet grower competes on fairly equal economic conditions with his brother cane grower in the South. The average cost of producing a ton of beets is $3, or $30 per acre, on the basis of $1.25 per day per laborer; while the average cost of producing a ton of cane is $2.00 to $3.00, on the basis of $1 per day per laborer.

Much has been said as to the inability of this country to compete with other sugar-producing countries, without a tariff on sugar imports. The question is naturally asked, how could the United States grow cane in competition with Java, where farm wages range from twenty-five to thirty cents per day; or how could we grow beets in competition with Germany, where farm wages are at least fifty per cent lower. Neither our experience of the past decade nor the analysis of the sugar facts in other

countries justify the conclusions of the ultra-protectionist or of the imaginary free trader. The admission of sugar from cheap-labor countries on a preferential tariff rate has not depressed the domestic production of sugar so much as the feeling of suspense and danger thrust upon the country by the uncertainty of the governmental policies with reference to the sugar tariff. As to the influence on the wholesale or retail price, it is worthy of note that the price in London varies but little from that of New York, and yet the English duty on imported sugar is less than one fourth that of the United States. In estimating the cost of production the efficiency and stability of the laborer is more important than the absolute wage rate, and the price of the finished product to the consumer is determined by a number of factors in addition to the cost of the laborers employed.

There is now a marked tendency to the enlargement and concentration of factory enterprises in the cane belt. This is made necessary by the installation of modern factory equipment, which, to be placed on a profitable basis, must be for the production of a large output. As a result the transportation problem has become a more difficult and a more expensive one to the cane grower. Only the largest plantations have improved facilities for the conveyance of the crop to the mill, this

being in most cases dummy railroad lines. The modern system, however, works to the advantage of the small grower, since the percentage of extraction by the best grinding processes in use at this time is twenty-five to forty per cent in excess of that obtained by the old system, when the grinding was done by the grower. The old horse-power mills extracted forty to fifty per cent of the juice, and even now about twenty per cent remains in the stalks as they come from the rollers; but the value of the increased yield more than covers the total cost of transporting the crop from the field to the factories.

The geographic situation of the cane-growing districts with reference to water and rail transportation, and with reference to the refining and market centers, are important conditions in determining the ability of a region to compete on a profitable basis. The producing zone in the United States is limited to the Gulf States in which the facilities for cheap water transportation are unexcelled, and all parts are admirably served by the more rapid railroad facilities. All parts of the belt are also easily accessible to the large refining centers, New Orleans, New York, Philadelphia, and Baltimore, which are also the most important market centers. The cheaper water transportation is available since the distance from any of the Gulf

ports to any of the Atlantic ports is not such as to occasion loss in the shipment of raw sugar in cargo lots. Because of the accessibility of the cane belt to the largest cities and the most densely populated States gives cane this appreciable advantage over the more remote beet-producing areas of the West.

Sugar cane can hold its place in any given region only so long as it is the most profitable crop. Already it has been supplanted in portions of the Gulf States by tobacco, cotton, rice, fruits, and vegetables; and the economic selection in the future is certain to be more discriminating than it has been in the past.

The cane belt has no greater need than the general introduction and practice of diversified agriculture, or the judicious rotation of crops. As astounding and unnatural as it may seem, the one crop system is still in vogue, not only in a large part of the cane belt but also in the cotton-growing regions. We can take courage since diversified production has gained ground more rapidly during the past five years. Intelligence, decrease in the "one-crop" yield, and misfortune are driving the issue. The delta planters stood unmoved until the sixty-per-cent cane crop of 1898, and the subsequent arrival of the boll weevil. One planter in the Yazoo delta writes that the boll weevil did not

strike him until last year, but succeeded in reducing his cotton crop from $35,000 to $11,000; and that, as a result, he has under cultivation this year 30 acres of cotton, compared with 700 last year, 300 acres of corn, and 50 acres of broom corn.

The adoption of diversified agriculture will have the effect of decentralizing the sugar-cane industry, of increasing the acreage yield, and of so fostering home industries—agricultural and manufacturing—as to lessen the risks and ameliorate the losses from adverse weather conditions, insect blight, and market depressions.

CHAPTER V

SUGAR CANE IN THE UNITED STATES

Of the staple agricultural crops sugar cane was one of the last to be launched successfully. Cereals, fruits, vegetables, cotton, and tobacco had been profitably cultivated by the Americans for more than a century prior to the introduction of sugar cane, and after its introduction more than a half century elapsed before the cane-sugar industry was more than experimental. It is impossible to discuss all of the reasons which led to this situation, but it is obvious that, from the standpoint of an open market and a constant demand, the manufacture of domestic sugar was desirable. It must be remembered that, until the early part of the nineteenth century, Florida and Louisiana were under the control of the Spanish and the French, but the trade relations between these nations and England continued amicable to the extent of commercial exchange, until our war for independence, and even until the acquisition of this southern coastal terri-

tory by the new republic. The Spanish, French, and Portuguese were active in exploiting the cultivation of sugar cane in the islands of the Atlantic and in South America. It was not, therefore, because the nations concerned were averse to extending the industry to this part of their producing and trading domain. Sugar was also a very acceptable commodity in the European trade, economically fitted for a return cargo on the ships engaged in the traffic of slaves, and all the nations active in the sugar trade were exploiting the African slave trade. There was also the inducement of a large domestic demand since the British colonists, and later the states of the Union, were dependent on the importation of sugar from the East and West Indies.

Remembering that the commercial production of sugar in this country did not become important until after 1825, let us consider some of the handicaps in the way of a more successful development. The absence of a cane adapted to the Gulf region, and ignorance as to methods of cultivation and manufacture must be recognized as the fundamental barriers which existed throughout the eighteenth century. We have already seen that the conversion of cane juice into sugar began to be successful in 1796, but a well-adapted variety of cane was not introduced until twenty-five years later.

Very early in the Spanish and French colonization in America indigo became an important crop, and a staple commodity of trade. This was the leading agricultural export from Louisiana and Florida as late as 1790. It seemed also impossible to obtain a labor supply which was adapted to the cultivation of cane. The problem was not simply one of cultivation, for the lands best adapted to the crop were not only veritable wildernesses, but almost uninhabitable to the white man from the standpoint of climate and disease. The largest crops could be harvested from the fertile loams of the valleys, but the utilization of these transgressed upon the fishing grounds of the Indians. These natural enemies could be overcome but slowly, and the Spanish and French personnel of these southern colonies was not calculated to make a determined and aggressive industrial attack. With the clearing and draining of the land the fatalities from disease decreased, and the Indians were steadily driven farther back into the wilderness. Following 1795, the insect ravages on the indigo plant became so destructive as to threaten this profitable crop, which made it all the more necessary to look to other sources of revenue. The French were especially interested in the tobacco trade and encouraged it in Louisiana, but the tobacco grown was inferior in quality, which prevented a rapid exten-

sion of its cultivation. Up to this time cotton had not been considered profitable for export, as is clearly indicated by the fact that in 1790 the United States supplied England with only one sixth of one per cent of her cotton imports. Besides, the cultivation of cotton began in southern Virginia, the northern limit of the cotton belt, and extended southward, so that it had only reached Florida and Louisiana in its experimental stage. Following the invention of the cotton gin in 1791, the cultivation of cotton increased with phenomenal rapidity, and soon became the most popular and profitable crop in the export trade. With the acquisition of Florida by the United States in 1819 the cultivation was soon extended to the Gulf Coast as far west as Texas.

In 1821 cane growing received a new impulse through the introduction into Louisiana of the striped, or ribbon cane, which proved to be much better adapted to the soil and climate of the Gulf Coast than the Creole variety. The production in Louisiana by 1825 reached 11,000 tons, and ten years later it was 51,000 tons, which during the next ten years was exactly doubled, and by 1855 had reached the encouraging status of 177,000 tons. The Civil War naturally paralyzed the cane industry, together with all other industries in the South. The total production in Louisiana in 1865

was but little more than 5,000 tons. The status of the industry preceding the War was most encouraging. Almost every grower of cane had his small sugar house, the number of sugar houses in 1850 being 1,490, which produced 154,000 tons of

HOPETON SUGAR PLANT AS IT APPEARED IN 1899.
Erected by James Hamilton Couper in 1829.

sugar. The great changes which have evolved subsequently in the distribution of factories becomes apparent when we consider that in 1908 there were only 200 factories in the state, which produced 335,000 tons of sugar. Following the Civil War sugar was able to regain its position but slowly on account of the great demand for cotton, which made it the most profitable crop in the Southern

States. We find, accordingly, that in 1875 the Louisiana sugar crop was only 60,000 tons, this being but little more than one third of the 1855 crop. Not until 1890 did sugar cane regain the position it held from 1850 to 1860. About 400,000 acres are now cultivated in cane, and the acreage is increasing each year. It is capable of almost unlimited extension since more than 10,000,000 acres are reported as admirably adapted to the profitable cultivation of cane. Much of this land, however, which is capable of producing enormous crops of cane, is also well adapted to rice and cotton. In recent years the rice crop has made inroads on the cane area in Louisiana and Texas, this having been brought about chiefly by the successful use of wheat harvesting machinery in harvesting the rice crop. Louisiana has 373,866 acres in rice, and in the leading rice centers sugar-cane production is waning. Calcasieu Parish has more than one third of the total rice acreage and only 480 acres in cane.

The fertile soils of the Louisiana cane belt produce twenty to forty tons of cane per acre. The factories pay for this product from eighty cents to one dollar per ton for each cent per pound commanded by the prime yellow clarified sugar on the New Orleans market. One ton of cane under the present process of economic milling and manufacture

yields 160 pounds of sugar. Under the old methods 50 pounds per ton was considered a satisfactory yield.

The cultivation at this time is concentrated in the central coastal counties of the state, where the soil is a deep fertile loam, the moisture conditions

Field of Sugar Cane, East Baton Rouge, La.

always favorable, and the rainfall adequate for a maximum production. St. Mary's Parish leads with 85,577 acres; Iberia is second, 40,000 acres; Assumption, third, 35,655 acres; and Lafourche, fourth, 33,000 acres. Although there has been a great advance in the method of cultivation and in the betterment of mill facilities, there is yet room for great improvement, particularly in the meth-

ods of cultivation. One of the most urgent demands for improving the cane production in the Southern cane belt is the establishment of adequate drainage. Although cane is a crop which requires a large amount of moisture, it must also have superior drainage for best results, so as to permit the free access of air into the soil. The drainage is in most regions effected by plowing the land in such a way as to leave it in ridges. The cultivation is then continued through the season so as to perpetuate the open furrows. The flood waters carry so much silt that underground drainage is expensive and difficult, because of the heavy deposition of silt from the waters flowing into the pipes. The sugar zone can be extended inland, as the typical yellow pine belt affords a cane crop which is even richer in sugar content than the coastal cane, but smaller in the tonnage yield. The Louisiana cane averages twelve to fifteen per cent sugar, this being somewhat below the average of Florida grown cane, and five to seven per cent below the average of the Cuban crop.

The possibility of extending the sugar cane area in Louisiana and other coastal states by swamp drainage is worthy of consideration. It is estimated that there are at least 5,000,000 acres of fertile land in the lower Mississippi Valley surrounding New Orleans which is susceptible to

reclamation. This soil when drained produces enormous yields of cane, cotton, or corn. The accumulation of humus has progressed with the accumulation of silt from the periodic overflows of the Mississippi River, giving it a balanced fertility of mineral and vegetable matter not excelled in any other region in the world. Louisiana and Florida are leading in the promotion of drainage reclamation, and the rapid rise in the price of land will greatly stimulate the Government and individual activities in extending the area of cultivation. On the reclaimed swamp lands sugar and rice are the most profitable crops.

There is no question but that the State of Louisiana is spending more money in investigating the problems connected with domestic sugar production than any other state in the Union. Not only is this experimental work telling most favorably on the production in the state, but the other cane-growing countries of the world are adopting many methods which had their origin in this state. Since 1885 the average acreage yield of cane in Louisiana has been doubled, and great hope is now entertained for the early development of a cane which will be better suited to the region than those which have been used since the industry was first established on a commercial basis.

The sugar-cane industry is being developed rap-

idly at present in the Red River Valley, the larger planting being stimulated by the disaster which has come to the cotton crops of the region through the boll weevil. This valley was a very important cane-growing region prior to the Civil War, but during the war the sugar and sirup houses were burned, and the high price of cotton immediately following the war enabled the cotton crop to supplant sugar cane, which had been the original money industry of the region.

Cane has never been grown extensively in Florida for purposes of sugar manufacture, but a considerable acreage is planted for the manufacture of sirup. More sugar was manufactured there from 1830 to 1860 than has been manufactured subsequently. As in the case of Louisiana, cane was only grown experimentally in Florida prior to 1825. In 1850, which is the first official record of the production, Florida produced 1,650 tons of sugar, which by 1870 had declined to 571 tons. The 1899 crop was only 142 tons. In the production of cane sirup Florida ranks third, having produced in 1899 1,687,000 gallons. The climate and soil in most parts of the state are admirably adapted to the production of sugar, the acreage yield varying from twenty to thirty tons, and the sugar content from eighteen to twenty per cent. The higher sugar content of Florida cane over Lou-

isiana cane is probably attributable to the longer season, since the crop is not harvested until December; whereas in Georgia and Louisiana, the harvesting begins early in November. Since the acquisition of Florida from the Spanish in 1819 the sugar industry has not gained ground there, as might have been expected from its climatic adaptation and geographic situation, chiefly because of the strong competition of other crops, which were either more profitable or better suited to the labor conditions of the country. Prior to the Civil War the cotton crop was rapidly extended in Florida, and this became even more profitable with the introduction of Sea Island cotton. Under the stimulus of the great industrial development in the Eastern States the seaboard cities increased in population with phenomenal rapidity, which brought to Florida the opportunity of reaping large profits from winter vegetables and fruits. Within more recent years, the Cuban and Sumatran tobaccos have been grown there with such success that the tobacco industry bids fair to compete successfully with the already firmly established industries of cotton growing, fruit growing, and trucking. Since all of these crops are becoming more profitable each year, and since there is little hope of larger profits in cane cultivation, except by increasing the production, the present prospect

is that sugar cane will continue to decline in Florida, in favor of more profitable crops.

The cultivation of cane in Georgia was begun in the first decade of the last century, but the success there was even less than in Louisiana and Florida. Small shipments of cane sugar were made as early as 1825, but the crop increased but little on account of the larger profits realized on cotton and rice. The acreage yield in Georgia compares favorably with that of the Gulf Coastal States, but the growing season is not sufficiently long to enable the cane to mature and then have time to mill it before the first frosts. The upland region of Georgia produces a cane which is richer in sugar than that of the alluvial lowlands and valleys. This is because of the better drainage, of the drier maturing season, which, together with the conditions of less fertility, make the crop mature earlier and in a shorter growing period.

The total sugar production of South Carolina in 1850 was 985 tons; in 1870, 386 tons; while that of 1899 was only 114 tons. The manufacture of cane sirup is, however, increasing, the total output being, in 1880, 1,565,000 gallons, as compared with 3,226,000 gallons in 1899. This gives the state first rank in the production of cane sirup, Alabama being second with a production of 2,672,000 gallons.

Sugar-cane cultivation is increasing rapidly in

Texas, the production in 1899 being 1,394 tons, while that of 1909 was 15,000 tons. Cane growing is confined at present chiefly in the lower valley of the Brazos River, with Fort Bend County as the largest producer. The prospects are that the cane crop will continue to be developed in this great state, particularly in the coastal region. Since its zone will be limited chiefly to within a hundred miles of the coast, it will have to compete with cotton, rice, fruits, and vegetables. In fact, the conditions of competition in this belt are more like those existing in Florida than elsewhere. The remoteness of the region from large population

TABLE III

RELATIVE STATUS OF THE SOUTHERN STATES IN THE PRODUCTION OF SUGAR CANE, 1850–1908

STATES	1850		1870	
	Sugar in Tons	Molasses and Sirup in Gallons	Sugar in Tons	Molasses and Sirup in Gallons
	(2,200 lbs.)		(2,200 lbs.)	
Louisiana	102,727	10,931,177	36,684	4,585,150
Texas	3,341	441,638	918	246,062
Florida	1,250	352,893	432	344,339
Georgia	746	216,150	292	553,192
So. Carolina	304	15,904	479	436,882
Mississippi	176	18,318	22	152,164
Alabama	3,746	83,428	14	166,009
Arkansas	.....	18	41	72,008
No. Carolina	.....	704	15	33,888
Tennessee	112	.....	640	.....

TABLE III—*Continued*

Relative Status of the Southern States in the Production of Sugar Cane

States	Sugar in Tons (2,200 lbs.)	Molasses and Sirup in Gallons	Acreage
1890			
Louisiana	132,774	14,341,081	193,694
Texas	2,491	2,159,339	16,284
Florida	769	1,441,744	9,345
Georgia	594	3,223,194	20,238
South Carolina	99	386,615	3,305
Mississippi	30	1,524,024	12,694
Alabama	177	2,333,231	19,415
Arkansas	.....	.....	.....
North Carolina	.....	.....	.....
Tennessee	.....	.....	.....
1900			
Louisiana	145,075	14,184,733	276,966
Texas	1,267	987,587	17,851
Florida	129	1,687,452	13,800
Georgia	103	3,226,367	26,066
South Carolina	44	805,064	7,342
Mississippi	8	1,413,219	11,352
Alabama	6	2,672,438	32,871
Arkansas	0	44,819	460
North Carolina	.....	1,957	.....
Tennessee	.....	.....	.....
1907–8			
Louisiana	335,000	.....	.....
Texas	11,818	.....	.....
Florida	3	2,398,000	7,307
Georgia	*1	*320,322	.....
South Carolina	.....	.....	.....
Mississippi	.....	.....	.....
Alabama	.....	.....	.....
Arkansas	.....	.....	.....
North Carolina	.....	.....	.....
Tennessee	.....	.....	.....

*1905–6.

centers makes the diversity of cultivation less than it would otherwise be. With the completion of the Panama Canal and the continued development of the vast and varied resources of the Southern States it may not be visionary to anticipate the time when all of this cane belt from the mouth of the Rio Grande to the Florida Peninsula will be called upon to feed a city population of many millions, in which event the profits from fruits and vegetables would become so large on land adapted to them as to cause a decentralization of sugar-cane culture, and give it a hard struggle for existence in the present intensive sugar-cane belt.

CHAPTER VI

SUGAR CANE IN OTHER COUNTRIES

HAWAII

When Captain Cook visited this group of islands in 1778, he found sugar cane growing wild in the lowlands, and cultivated on the uplands by the natives. They made no use of it in the manufacture of sugar, but used it in the raw state as a food. The first commercial factory was erected in 1835 by Ladd & Company at Koloa, on the island of Kauai. The export of 1837 amounted to only $300, but other mills were constructed and the 1840 export amounted to $18,000. The experiment, however, did not prove a commercial success until 1858, when steam power and the modern vacuum pans were introduced. The high price of sugar during the Civil War greatly stimulated the cultivation of sugar in the islands. It received further impulse from the reciprocity treaty with the United States in 1876, which practically created free-trade relations. The last quarter of the

century showed phenomenal growth, the production increasing from 13,036 short tons in 1876 to 271,049 short tons in 1899, or an increase of 1,979 per cent. It is true that the sugar industry has been exploited in Hawaii to the suppression of other industries, which has resulted in a continuous concentration of capital. The scarcity of labor is the most serious handicap to the further development of the industry. Immigration has been entirely inadequate to meet the labor demand since the Chinese exclusion law became effective by annexation in 1898.

The islands are of volcanic origin, and most of the sugar-cane lands are situated at the base of the mountains, so that they consist of a deep fertile alluvial soil brought down from the surrounding mountains. The islands have two distinct types of weather on the windward and leeward sides, the rainfall being heavy on the former and light on the latter. Irrigation must be practiced on the dry, or leeward side, but here the cane production is about double and the cultivation most satisfactory. The average production of cane in Hawaii is about 34 tons per acre, yielding 8,300 pounds of sugar, while in certain favored localities it is as high as 70 tons per acre. Not only is the acreage output the highest of any cane-growing country, but the sugar content—1 ton of sugar to 82

tons of cane—is higher than in any other country. Hawaii also leads the cane-growing world in the mechanical facilities of her mills and refineries.

Following the prohibition by Japan of immigrants to Hawaii the labor situation became a serious handicap in the development of the sugar-cane industry. The problem is being satisfactorily solved by the importation of laborers from the Philippine Islands, Russia, and Portugal. The Russians are considered the most efficient laborers on the island.

The total production in 1908 was 465,000 short tons, more than 450,000 tons of which were exported to the United States. The production in 1909 was 477,000 tons, and the export to the United States was valued at $38,500,000. Cuba is the only country having a larger sugar export to this country.

CUBA

Although sugar cane was introduced into Cuba early in the sixteenth century (1511), the industry there did not develop into commanding commercial importance until the eighteenth century, during which it developed rapidly under the stimulus of a vigorous slave trade. By 1800 the annual export from Havana reached 20,000 short

tons, which by 1820 increased to 50,000 tons. It now became the predominant industry, and Cuba soon took her place in the front rank of the cane-growing countries, being never closely rivaled or exceeded by any, save by little Java under the guidance of the wily Dutchman. The production in 1850 was 300,000 tons; in 1870, 726,000 tons; in 1900, 600,000 tons; in 1908, 961,958 tons; and in 1909, 1,513,582 tons, which represented Cuba's high-water mark in sugar production. Although 850,000 acres are cultivated in cane it is estimated that this is only one fourteenth of the area adapted to its cultivation. Cuba has a total of 116 sugar factories, of which 76 are owned by Spanish, French, and English, 72 by native Cubans, and 38 by Americans. The present tendency is toward the enlargement of sugar plantations and the centralizing of factories for a more economical production with improved machinery. The Cuban factories have an average tonnage output more than three times that of the Louisiana factories. The lack of adequate and efficient laborers is the most serious handicap in the way of increasing the sugar production on the island.

The Cuban sugars are admitted on a preferential tariff rate of twenty per cent reduction, as a result of which practically all of the surplus is exported to the United States. The total crop in

1908 was 961,958 tons, of which 916,742 tons were exported to the United States.

Being in the Trade Wind belt the island is subject to the violent West India hurricanes, which are fatally destructive to the cane crop. The soils are fertile and the rainfall abundant, especially during the period from May to October. Cane cultivation is largely limited to the three provinces of Havana, Cienfuegos, and Santiago de Cuba, in which the proportion is approximately thirty-eight, thirty-three, and twenty-nine per cent. From five to ten crops are harvested from one planting. Improvement in cultivation is in progress, and labor-saving facilities are being vigorously installed on the large plantations. The decline in the price of sugar during recent years has lowered the margin of profit, and set up a competitive struggle so severe as to make necessary a general readjustment of the industry. In 1876 the price of Cuban sugar was eleven cents per pound, and the cost of labor less then than now. Since 1900 the factory price to the producer has seldom risen above two and a half cents per pound. Even at this price a small profit is realized over the present cost of production.

PORTO RICO

Proportionate to its size, the island of Porto Rico is an important grower of sugar cane, having an

area of only 3,668 square miles. Coffee and sugar cane are the two leading crops on the island. Coffee ranks first in area (122,000 acres) and second in value, while sugar is second in area and first in value, the sugar export being more than double the coffee export. The cultivation of cane is limited almost exclusively to the coastal region, which consists of a deep, fertile, sandy, alluvial soil. The rainfall in Porto Rico does not differ materially from that of Cuba both in amount and distribution. Two thirds of the rain falls in the summer and autumn. The island is also subject to the West India hurricanes, which constitute a constant menace to the sugar industry. Since 1898, the year in which the United States took formal possession of Porto Rico, there has been marked progress in the industrial development of the island. The steady demand for sugar in the United States and the admission of sugar free from Porto Rico have greatly stimulated its cultivation, the crop having increased during the past decade from 50,000 to 250,000 tons. Not only has there been a great extension of the sugar industry, but a reorganization of the industry through the consolidation of small plantations into large holdings, most of which are owned by New York capitalists. Sugar having proven the more profitable crop, has been developed at the expense of the coffee crop, as a result of which the

Porto Rican sugar export under American management has increased from $2,500,000 to $19,000,000, while during the same period, the coffee export declined from $7,500,000 to $4,500,000.

PHILIPPINES

This group of islands is exceptionally well adapted to the production of cane, but the industry has made little progress during the past cen-

SUGAR REFINERY IN THE PHILIPPINES.

tury. The adaptability of the region for profitable production makes it well deserve the name, "Pearl of the Orient," but the gem character has been

much blurred by the reign of ignorance and neglect. No country of the tropical zone has a more favorable climate. The mean annual temperature is about 80° F., the natural drainage good, and the soil very fertile.

The crop in 1880 was estimated at 175,000 tons.

GATHERING SUGAR CANE IN THE PHILIPPINES.

The average annual export from 1880 to 1898 was 261,000 tons, and this surplus was obtained by the most crude and wasteful methods of cultivation and manufacture. Only about fifty per cent of the juice is extracted from the cane, and yet the scale of wages is so low that the cost of production has ranged from 65 cents to 90 cents per hundred

pounds. The Spanish, during their possession of the Archipelago, did little toward improving the methods of production. Their chief attention was directed to exploiting the productions of the ignorant natives instead of improving the methods of production. Notwithstanding the progress in the establishment of sound and profitable trade relations under the amicable guardianship of the United States Government, no striking results have been realized in the expansion of the sugar industry. A combination of reasons account for this situation. The exceptionally high price of hemp and copra stimulated these products to the relative depression of sugar. Also worthy of mention is the fact that the policy of the United States has been to train the people to a capacity for self-government and industrial initiative. To foster this realization foreign capital has not been indiscriminately encouraged, but is gradually finding its way into the islands.

The educational end of agricultural production is now receiving special attention in the teaching of elementary agriculture in the public schools, the establishment of Experimental Stations and Experimental Farms, and the wide distribution of agricultural literature.

The Philippine sugar is admitted into the United States on a preferential tariff of twenty-five per

cent reduction, and since there is a refundment of the duty collected to the Philippine Government, it amounts to admission free. The sugar export from the Philippines in 1907 was 188,395 tons, while the export of 1908 was 149,323 tons. It is expected with confidence that within the next decade the sugar export from the Philippines will be doubled, provided the present tariff rate is continued, and more than doubled if the Philippine sugar be placed on the free list.

MEXICO

Cane was introduced into Mexico by Cortez, who established in Izcalpam (Mexico) two sugar plantations. By 1553 Mexico was exporting sugar to Spain and Peru. It was, therefore, the first region of the continental part of the New World to export cane sugar. The industry, however, made little headway during the next two centuries, and has never been developed on a scale commensurate with the opportunity. The economic conditions are favorable for an enlarged production. The cultivation can be greatly extended in the coastal region, in which the cane grows luxuriantly for many seasons from one planting. Large areas of the uplands could be profitably utilized by the introduction of irrigation, for

which the conditions are favorable. The labor situation in Mexico is less perplexing than in most of the cane-growing countries, since the mountain environment of the coastal zone makes it easier to supply skilled laborers and intelligent supervision.

Outside capital is now being invested in lands destined for sugar plantations. One company has purchased 600,000 acres in the Sonora Valley, which is reported to be well adapted to the cultivation of sugar cane.

The total production in 1899 was 67,000 tons, as compared with 143,179 tons in 1909. The largest producing states are Morelos, Vera Cruz, and Puebla. The molasses production during 1908 aggregated 70,947 tons, the greater part of which was converted into alcoholic drinks.

CENTRAL AMERICA

All of the Central American states are situated in the cane-growing zone, and large areas above 4,000 feet elevation are adapted in soil and climatic conditions to the production of sugar beets. Though all of the states produce some cane sugar, it is not an important export. Coffee, rubber, hemp, cocoa, and lumber are the chief exports, and the sugar industry is not competing success-

fully with these commodities, most of which require less labor and are not so dependent on expensive transportation margins. The coastal plain on the Atlantic side is broad, very fertile, and has a humid tropical climate, there being no dry season east of the mountains. For the profitable development of the sugar industry much well-directed labor would have to be expended, and the climatic conditions are neither attractive to the best class of laborers nor conducive to a thorough and skilled performance. Where sugar cane is grown the average cost is one and a half cents per pound, which is about the average cost in the West Indies. The total crop of Central America in 1909 was near 20,000 tons, of which Guatemala and San Salvador produced more than one half. The small surplus is shipped almost exclusively to Europe.

DUTCH EAST INDIES

Of the Dutch East Indies, Java is the only important grower of cane, though all of the islands of the group are admirably adapted to a profitable production. Although rice is the most important crop, since it is the basis of the food supply for the native population, sugar is by far the largest export, and is being developed more

rapidly than any other industry. In 1897 Java produced 546,750 tons of sugar, which by 1899 had risen to 796,324 tons. The production in 1909 was 1,241,885 tons, which gave Java first rank among the cane-growing countries. There are 177 sugar plantations on the island, most of which are owned by capitalists who reside in Holland. The 30,000,000 natives of the island are dominated by the 60,000 Hollanders who are employed to direct the great industrial interests of their countrymen. Under this régime the industrial development has done very little to improve the condition of the native Javanese. The labor scale is low, the average wage being twenty-five cents per day to male laborers and twelve cents to female. This enables the Dutch plantation owners to produce sugar at less than one cent per pound on land of only average fertility. It is affirmed that, when raw sugar commands a price of one and a half cents per pound, the plantation proprietors realize a profit of forty per cent. For the purpose of fostering the production of sugar from beets in the home land, as well as for maintaining the price of Java sugar on the market, the Dutch Government enacted laws prohibiting the further expansion of the cane-sugar industry in Java. The industrial interests are further protected by laws which prohibit the refining of raw sugar in Holland.

Until recent years the Java sugar export was purchased almost exclusively by the United Kingdom and the United States, but China and India are now becoming conspicuous in the trade. This trade will continue to increase, as the consumption of sugar in Asia is increasing steadily and China has a comparatively small area adapted to sugar cane since the loss of Formosa. Within recent years the European export to India has steadily declined, and the import from Java has proportionately increased, constituting in 1908 sixty-three per cent of India's total sugar imports. The amount of sugar which is exported from Java to the United States varies from year to year, depending upon the varying conditions of the supply from the countries whose sugar is admitted either free or on a preferential tariff rate. In 1908 the United States' sugar import from the Dutch East Indies was valued at $11,000,000.

The sugar zone in Java extends from the coast up to an elevation of 2,000 feet. The rainfall is adequate throughout the year, but the rainy season lasts from October to April. From April to October is a period of perpetual sunshine, broken at frequent intervals by short and light showers.

SOUTH AMERICA

There is probably a larger area in South America adapted to the cultivation of cane than in any other continent. Brazil, Argentina and Peru lead in production, having grown about four fifths of the South American cane crop in 1909.

Brazil ranks first, with a total production in 1909 of 248,000 tons. More than half of this total was produced in the Pernambuco Province, where the climatic and soil conditions are ideal for a luxuriant growth of cane. All of the coastal region of Brazil is adapted to cane cultivation, as well as many of the fertile valleys which extend inland. The methods of cultivation and manufacture are not modern, except on a few large plantations, as evidenced by the fact that the sugar extracted is about seven per cent, or one half of the sugar content. The lack of available capital is reported to be the most serious handicap to the development of the sugar industry in this country, since most of the factory owners are land poor, and in the attempt to control large estates have neither sufficient capital for the development of the estates nor for the economic manufacture of the crop. The sugar industry is overshadowed in the southern and eastern parts of the Republic by the coffee industry, which in reality overshad-

ows all other industries as a source of wealth. In the great Amazon Valley the sugar industry is precluded by the rubber industry. The total sugar export from Brazil in 1909 was valued at $2,000,000. Practically all of this surplus is sold to the United Kingdom. Prior to our enlarged sugar trade with the noncontiguous territory acquired by the United States a considerable part of Brazil's sugar export was purchased by the United States.

Argentina is not so well suited to the cultivation of cane as Brazil, but large areas in the northern subtropical belt are capable of producing a profitable yield. The total crop of 1909 yielded 162,479 tons, compared with a production in 1898 of 60,000 tons. Unlike Brazil, the largest sugar-producing province, Tucuman, is far removed from the coast, being situated on the lower slopes of the Andes. This proximity to the high mountains gives an abundant rainfall throughout the year.

British, Dutch, and French Guiana have a wide coastal plain, which, being in the heart of the tropics and in the trade-wind belt, is very favorably situated for a luxuriant yield of cane, and it has been one of the most important export crops during the past two centuries. The production in each division of the province is fostered with reference to the particular demand in the market of the respective home country.

British Guiana had 69,500 acres in cane cultivation in 1909, of which 65,000 acres were harvested. The total sugar production was 110,000 tons, making an average of 1.7 tons per acre. Sugar cane continues the largest agricultural resource of the colony. Much of it is utilized in the manufacture of rum, the 1908–9 production being 2,500,000 gallons. The plantation owners report great difficulty in obtaining laborers during the harvest season, and this complaint seems to be general in the cane-growing countries of the world.

In Venezuela the production of sugar is not in excess of the consumption. The coastal region is here narrowed by the eastward extension of a branch of the Andes, which passes beyond the coast line and seems to reappear in the West India Island group. The lower valley of the Orinoco is very fertile and capable of a generous yield of all kinds of tropical products, but only small areas have been reclaimed from its virgin wildness.

In latitude Colombia lies wholly in the tropical zone, and has a narrow coastal region on the Pacific side and a broader coastal region on the Atlantic side well adapted to cane. The rainfall throughout the lowlands of Colombia is heavy, which, combined with the excessive heat and the poor drainage, makes the region unhealthy, as a result of which the cultivated lands are to be found chiefly

at higher elevations, where coffee and tobacco become the most profitable crops.

Practically all of the cultivatable part of Ecuador below 4,000 feet elevation will grow sugar cane successfully. The annual output is about 8,000 tons, which no more than meets the home demand. The narrow coastal region and the limited valley areas make Ecuador less adapted to sugar production than the other countries of South America previously considered.

Peru is the third largest sugar-producing country of the continent, the 1908 crop being estimated at 150,000 tons. Cane cultivation is limited to the coastal region, while coffee cultivation becomes important on the central plateau. Much of the sugar surplus of Peru is shipped south to Chili, which is not a cane-growing country. The sugar export during the first six months of 1909 was $455,000.

BRITISH WEST INDIES

The sugar industry has experienced significant changes in the islands of the British West Indies during the past decade. The old system of cultivation and manufacture is being rapidly discarded through the purchase of the sugar interests by large corporations, headed by European and American capitalists. The West India group of islands

was the center of the sugar production during the sixteenth and seventeenth centuries. The industry flourished there under slavery, and rapidly declined in the early decades of the nineteenth century while adjusting itself to the new conditions of a free-labor system.

Trinidad cultivates from 65,000 to 70,000 acres in cane annually, and produced in 1909 44,512 tons of sugar. Most of this sugar is refined on the island.

Jamaica produces an average of 12,000 tons and exports about five sixths, which is sold almost exclusively to England and Canada. Jamaica makes extensive use of cane in the manufacture of rum, exporting more than one million gallons annually. The cultivation of cane has declined in the island since 1880 in favor of tropical fruits and cocoa.

The sugar plantations of the Barbados are large, and owned and operated almost exclusively by Englishmen. The system of development seems to be largely of the spoils-gathering character, which is not calculated to establish permanent and sound economic conditions. The export in 1908 was 29,340 tons. Most of this goes to Canada, since Canada admits sugar from British colonies on a preferential tariff rate.

FRENCH WEST INDIES

Prior to 1880 sugar and rum were almost the only exports from Guadeloupe and Martinique. Between 1880 and 1900 the total trade declined more than thirty per cent, due chiefly to the strong competition with beet sugar. Since 1900 more attention has been given to the production of tobacco, fruits, and cocoa. Sugar is still an important export, amounting to 75,000 tons in 1908.

HAITI AND SAN DOMINGO

The sugar industry is declining in both of these islands. Haiti's incapable and unstable government, resulting from a similar citizenship, makes industrial development and prosperity impossible. The decline in San Domingo is largely attributable to the supplanting of cane by cocoa, which gives a larger return on the investment.

BRITISH INDIA

Cane cultivation is being rapidly increased in British India, but only general estimates can be made in the absence of accurate statistics. The British Government estimated the total area in cane at 2,876,965 acres in 1908, and a total pro-

duction of 2,054,700 tons. On this basis the annual cane-sugar production is 3,411,000 tons. To this must be added the palm-sugar production, which in Bengal was estimated at 163,000 tons for 1908. Modern British India, composed mostly of ancient Hindostan, is the largest sugar-producing country of the world, and the per capita consumption is from twenty to twenty-five pounds per year. If India and China were as large per capita consumers as the United States, the present world production of sugar would not more than meet the demand in these two Asiatic countries. The methods of cultivation, harvesting, and extraction are very crude. In many places the old wooden mills are still in use, which do not extract more than thirty to fifty per cent of the juice. Bengal is the most important cane-growing district, producing one fifth to one third of the total.

The total import of sugar into British India during 1907–8 was reported at 11,180,000 hundredweight, valued at £6,151,000. Of this total Java supplied sixty-three per cent and Mauritius twenty-eight per cent. With the rapid increase of the import from Java has come a proportionate decrease in the amount of beet sugar imported from Europe.

CHINA

Sugar cane has been cultivated in China for many centuries. The consumption of sugar by the Chinese is heavy, which makes necessary a large importation from the Straits region, Java, etc. Hong Kong is the largest refining center. The total domestic production in the empire is more than 200,000 tons, a part of which is exported, but the sugar imports far exceed the exports. The coastal region of the southern and middle provinces are the most important producers of cane, and large areas of sorghum are cultivated in the northern provinces. The native Chinese varieties of cane are very hard, which makes them immune to the ravages of the white ants, so destructive in China, India, and the East Indies.

The Chinese people are now learning to use sugar in their tea, which is increasing rapidly the consumption of sugar in that country. With a territory differing but little in area from the United States, exclusive of Alaska, the Empire maintains a population of about 400,000,000. Comparatively small areas are adapted to the production of sugar cane, and the possibilities of beet culture have not been tested. It therefore seems certain that with the increased consumption of sugar in China must come a proportionate increase in the sugar import.

The economic conditions of the country naturally preclude the possibility of the Chinese becoming as large consumers of sugar as are the people of the United States, but should the Chinese cultivate a "sweet taste" in the consumption of rice as they are cultivating it in the consumption of tea, they would, under present economic conditions, become very large consumers of sugar, unless the price of the commodity increased above the present averages.

JAPAN-FORMOSA

The sugar industry is being exploited with great activity on the island of Formosa by the Japanese, who are also making every effort to control the sugar market and manufacture in China. The Formosan sugar enters Japan duty free. Exclusive of Formosa, Japan's sugar imports in 1908 were estimated at $10,000,000. The bulk of this came from the Dutch East Indies, but the refined sugar came from Germany and Austria-Hungary.

The Japanese acquired Formosa in 1894, but had to reconquer it, and did not complete the reconquest until 1898. Sugar, tea, camphor, and rice were the most important exports at the time of the Japanese occupation, and they early began the development of the sugar-cane industry. Mod-

ern mills are being constructed, and nine companies now have a capitalization of $5,851,500. The sugar bureau of Formosa offers a subsidy of fertilizers to the value of twenty yen ($9.96) per kah (2.45 acres) of rose-bamboo cane planted. The average yield per acre is fourteen tons. Until 1902 the old stone mills were in general use, and extracted only forty-five per cent of the juice. The most modern of the new mills average seventy-eight per cent extraction. The present cultivation is limited almost exclusively to the southern part of the island.

AUSTRALIA

Sugar cane was first cultivated in Queensland in 1862, and is now the most productive agricultural resource. The sugar-zone is limited to the fertile coastal region, where there is ample room for a great development of the industry. The production increased from 148,000 tons in 1904 to 184,375 tons in 1908. The cane yield per acre was 17.6 tons, which gave an average of 1.88 tons of sugar. The present production about meets the domestic demand. The per capita consumption in Queensland in 1908 was 102.4 pounds.

Cane was first cultivated in New South Wales in 1824, but has not made satisfactory progress. From 1870 to 1890 the acreage increased from

3,900 acres to 18,000 acres, and has changed but little since 1890. The total production in 1908 was 23,418 tons. There is also a limited cultivation in Victoria, South Australia, West Australia, and Tasmania.

AFRICA

Egypt is the most important cane-growing country of continental Africa. It flourishes on the moist lowland region of the great Nile delta, but it is not gaining in its competition with cotton, tobacco, and rice, each of which has become more profitable within the past two decades. The crop of 1909 produced 55,000 tons of sugar, which was a substantial increase over 1908.

Sugar cane is the only important crop on the Mauritius Island, the total production of which in 1909 was estimated at 195,000 tons.

The crop grows luxuriantly in the Congo Valley and has long been utilized by the natives for consumption in the raw condition from the stalk. Experimentation is in progress on the eastern coast of Africa, where the prospects are favorable for a profitable establishment of the industry. The cane matures well and averages from fifteen to twenty per cent sugar.

In 1908, 12,665 acres were cultivated in cane in the Zambesi Valley, which produced 12,665 tons of

sugar. The acreage yield runs as high as 60 tons. The first crop requires fifteen months for maturing, after which the canes produce an annual crop. The inability to obtain laborers is the only serious obstacle to the extension of the industry.

CHAPTER VII

CONTROLLING FACTORS IN THE PRODUCTION OF SUGAR BEETS

The climatic conditions required for the most profitable production of sugar beets differ materially from the conditions enumerated as most favorable for the production of sugar cane. Although beets will grow throughout a wide latitude zone extending from the heat of the tropics into the very shadow of the subarctic zone, still the belt which matures a beet of high sugar content is comparatively narrow. The average annual temperature is not so important in the production of beets as the temperature conditions during the growing season—June, July, and August. Most of the beet-producing countries have a mean annual temperature of 60° to 65° F.

The exact temperature conditions are not so vitally important as the distribution of the rainfall, the condition of humidity, the percentage of sunshine, and the length of the growing season. The quality of the beet is best conserved by the follow-

ing conditions: an abundant winter rainfall; an average spring rainfall distributed in local showers, with a large percentage of days of sunshine; an average rainfall during June and July, interspersed with hot sunshine; followed by drier conditions in August and September; and dry and cool weather during October and November. This distribution of temperature and rainfall gives the plant sufficient moisture for a vigorous start, enables the farmer to cultivate the crop thoroughly in its first stages, thereby clearing out the weeds and grasses, supplies the moisture which is necessary in the height of the growing season (June and July), and affords the most favorable conditions during the maturing stages for realizing the highest sugar content. A late and cool autumn is especially desirable, not only for the purpose of having sufficient time in which to harvest and manufacture the crop, but for the sake of protecting the crop against deterioration, which rapidly takes place in warm and moist autumn weather if the beets are left in the ground. Because of the difficulty of obtaining the ideal climatic conditions for the most favorable production of beets, the best results are realized by irrigation. This is emphatically true in the United States, since large areas of the arid and semi-arid West are situated in the theoretical beet belt previously mentioned.

The soil condition is only second in importance to the climatic condition. In the selection of a good beet soil the physical properties must be considered as well as those of fertility. The crop is rapid in growth and large in tonnage, so that it is positively

Correct Position of Mature Beet in Soil.

necessary to have an abundant supply of plant food easily available. Supposing the presence of this, the drainage conditions must be good to insure a thorough ventilation of the soil, which is necessary for the rapid assimilation of the plant food. The beet root is relatively large and long, and for perfect development requires a deep soil of fine

and even texture, otherwise the roots will be of very irregular shape. A soil which is typically sandy does not carry sufficient plant food, and a

Well-formed Beet.

Effect of Bad Sub-soil.

heavy clay does not afford the physical condition necessary for the normal development of perfect roots. Since the beet crop requires an abundance of lime as one of the plant foods, a calcareous loam of strong clay admixture seems best adapted from the standpoint of plant food, and fulfills the physical requirements. Obviously a rocky soil is not adapted to the maturing of a root crop; neither

are the mucky and peaty soils of low, alluvial lands adapted on account of the surplus water supply, which prevents the free admission of the air so necessary for assimilating the elements of nutrition. Black alkali soils and soils containing a large percentage of salt (sodium chloride) cannot be utilized in the cultivation of beets.

The beet growers are awaking to the importance and the necessity of returning fertility to the land to compensate for that consumed in maturing the beet crop. The crop is not so exhaustive as corn, wheat, and tobacco, but more exhaustive than potatoes, beans, and grasses. Beets being heavy consumers of nitrogen, potash, and lime, naturally respond profitably to the application of these fertilizers, which not only increase the tonnage of beets, but the percentage of sugar. The highest tonnage yields have been obtained by the generous application of stable manure, but the crops in each case gave a lower percentage of sugar than was realized from land treated with commercial fertilizers bearing the above-named constituents, and a lower percentage than was obtained from plots having no fertilizer application.

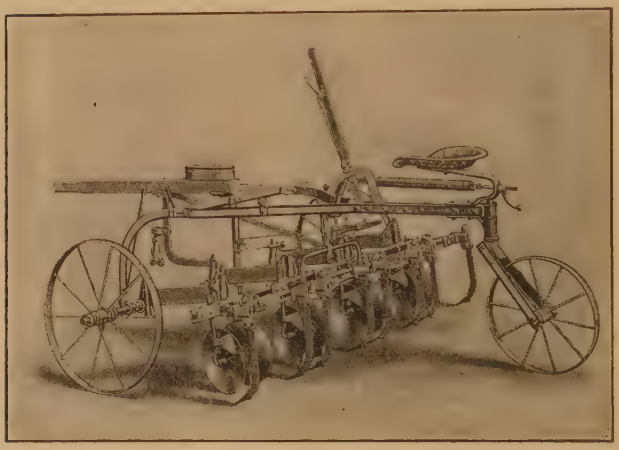
One of the most important factors for consideration is the improvement and selection of the seed. We have seen in a previous chapter how much has been accomplished toward increasing the sugar

content by improvements in seed selection. In fact, the amount of sugar which a beet contains depends largely on the climate, the cultivation, the soil, and the seed. The beet which gives the highest sugar return is of medium size, pear shape, large leaf, but relatively small top. It has also been found that by increasing the size of an accredited variety, the root becomes more watery, of coarser texture, and of lower sugar content.

It seems advisable to practice in most places autumn plowing for beets, thereby leaving the land fallow during the winter. The plowing should be systematically deep, not only for the purpose of stirring the soil to make available a large supply of plant food, but also for the preparation of an adequate root bed in which the plant can develop without hindrance. Unless the soil is very rich in natural fertilizer ingredients, it becomes necessary to apply generously commercial fertilizer. The beet is a crop which requires constant cultivation during the early part of the growing season to conserve the moisture and kill out the weeds and grasses, which become robbers of the money crop. If the land has been cleaned of grass and weed seeds, the cultivation after thinning can be successfully conducted by machinery—in fact, more successfully than can be done with the cane crop.

The beet crop is subject to a number of enemies,

the most important of which are the beet army worm, the wireworm, the beetworm, beetles, plant lice, grasshoppers, and a number of fungous diseases. The most important of the fungous dis-



Modern Beet Cultivator.

eases are "beet scab," "leaf spot," "curly top," and "root rot." Some of these enemies feed upon the root, while others feed upon the tops. "Curly top" and grasshoppers are much more destructive in the irrigated regions of the west, while "root rot" is decidedly more common and destructive in the humid east. It is to be regretted that the enemies to the beet crop are becoming more widespread and destructive each year.

The value of beets is proportionate to the percentage of sugar content and the tonnage. There is a wide variation in the amount of sugar yielded by the crops of different countries, and yet all of the beet-producing countries have so improved the varieties and the methods as to produce beets which average more than ten per cent of sugar. Fifty years ago this average was not realized in the countries best adapted to the crop. Many of the manufacturers purchase the beets on a sliding scale, based upon the percentage of sugar. This rule is not so general in the United States as it is in the countries of Europe. In 1880 France was only extracting five per cent sugar, while Germany was extracting a little more than ten per cent. The difference in the sugar content was such as to enable Germany to produce sugar at one half the cost of production in France, granting that the other expense items were identical. The variation in the United States is almost as marked, since the average sugar content in the beet-growing region of Michigan seldom exceeds twelve per cent, while the average in certain parts of Colorado, Idaho, and California runs as high as twenty-two per cent. It so happens, however, that in the states producing beets of the highest sugar content, wages are higher, land values higher, and the cost of production increased

greatly by the necessity for irrigation. This more or less balances the economic conditions which enter into the competition.

The labor cost is a very important item in the production of beet sugar. It is necessary that cultivation be thorough and continuous, and although labor-saving machinery may be utilized to advantage in the cultivation, no satisfactory machine has

HARVESTING A FIELD OF SUGAR BEETS.

yet been invented either for topping the beets or harvesting them. The United States stands out conspicuously among the countries of the earth in the high scale of wages maintained, and yet the price paid to the grower of beets in this country is less than in France, Germany, Belgium, or Austria. In 1908 the American factories paid from

$4.75 to $5.75 per ton for beets, while the average price during the same year in Germany was $5 to $6, and in France $7. It is encouraging to note, however, that the price paid for beets at American factories has increased more than thirty per cent since 1900.

Loss in Capping.
Beet forced out of ground during growth.

The cost of transporting beets from the field to the factory is an important item of cost. It is estimated to cost at the rate of forty cents per ton for the first mile and twenty-five cents per ton for each succeeding mile. From this it is obvious that a ten-mile haul on wagons would make the cost prohibitive at the current prices of beets at the factories.

Government bounties and tariffs naturally influence vitally the conditions of competition in any producing country. All of the beet-growing countries of Europe place a duty on the sugar produced in their respective colonies or on that produced

in the home country. This serves the dual purpose of protecting the beet-sugar industry on the continent, and of affording an important source of revenue. The duty is 2.5 cents per pound in France, 2 cents in Germany, 1.82 cents in Belgium, 7.7 cents in Spain, 8.8 cents in Russia, and 3.1 cents in Roumania. Even free-trade England imposes a duty of 45.5 cents per hundred-weight (112 pounds) on imported sugar. The United States has protected the domestic industry by placing a duty of $1.68\frac{1}{2}$ on 96° sugar from foreign countries.

As to whether the cultivation of beets and the manufacture of beet sugar in any given locality will prove a permanent success depends in a large measure upon whether the region is adapted to crops productive of larger profits. As an illustration, Idaho during the past decade has made rapid strides in the expansion of her beet-sugar interests, but just now there is quite a reaction because of the larger profits which many individuals have realized on fruits and vegetables. Land which was salable at $75 to $100 per acre as beet land has suddenly risen in price to $150 to $300 per acre for fruit growing. We must, therefore, expect the beet industry to readjust itself from time to time with reference to new discoveries and new adaptations.

In figuring the cost of production the by-prod-

ucts must be counted as one of the assets to the industry. All the by-products from the manufacture of sugar from beets are valuable for stock-feeding purposes. The farmer can, therefore, feed the tops and the pulp from the mill, and in this incidental way help to provide for the live stock of the farm.

With our transportation facilities the geographic situation of the region is not of the importance it was formerly, but still it constitutes an important economic factor in the distribution of a large production of any staple commodity. In the United States the domestic sugar supply is fortunately well distributed, since the Atlantic seaboard represents the refining zone for the imported raw sugars, and the great beet zone of the west provides a partial sugar supply for that constantly increasing population west of the Mississippi River. In the refining of raw cane sugar large plants are the rule, while in the manufacture of beet sugar each milling station represents a refining station. We find, therefore, that the larger centers of the east, which are directly in touch with the factories and with the world's sugar trade, hold the price-fixing power.

CHAPTER VIII

RISE OF THE BEET-SUGAR INDUSTRY

The extraction of sugar from beets dates back to 1747, when Andrew Marggraf, chemist in the University of Berlin, discovered the existence of a sugar in beets similar in its properties to that obtained from cane. He succeeded in extracting only about three per cent. The discovery was, however, little utilized, as the manufacture of sugar from beets did not attain commercial importance for almost a century. It remained for Francis Karl Achard, a pupil of Marggraf, to make inventions and discoveries for launching the industry commercially. His success aroused the interest of Frederick William III, King of Prussia, who aided in the construction of the first beet-sugar factory of the world. This was built in 1799 on the Cunern estate, near Steinau, in Silesia. It was followed by others in Prussia, Bohemia, and France. Not only was the actual amount of sugar contained in the beets small, but the methods of extraction

were crude and inadequate. The production of sugar from sugar cane was also increasing rapidly during this period, so that the increased sugar supply militated against the rise of the new industry. The German chemists were not indifferent to the future possibilities of this source of sugar, and were making substantial progress in methods of extraction when England blockaded the ports of continental Europe during the Napoleonic wars. This blockade effectually cut off the cane sugar supply to continental Europe, and naturally had the effect of greatly stimulating both the French and the Germans in their experimentations. In 1806 the French Government offered the first bounty on the production of beet sugar. The supply of sugar in France and the other European countries was being rapidly exhausted, and the price was being raised to prohibitory rates, the average price of sugar in France from 1807 to 1815 being thirty cents per pound. The first French factory was constructed in 1811 near Lille, on the estate of Crespel-Delisse. The French Government appropriated in 1812, 1,000,000 francs for perfecting experiments on beets as a commercial source of sugar. In this year France had 16,758 acres cultivated in beets. The total beet crop milled was 98,813 tons, which yielded 1,650 tons of sugar. Forty small factories were in operation in France,

but with the annulment of the continental blockade cane sugar was placed on the market at a price so low as to close many of these factories. The total sugar production in 1827 was estimated at 1,000 tons, a decline of forty per cent in fifteen years. Because of the greater inducements offered by the government, the greatest expansion of the beet-sugar industry in the early part of the nineteenth century was experienced in France.

The Germans, however, were achieving more on the scientific and technical side, which was destined to bring them later to the forefront among the beet-growing countries of the world. They were also making rapid progress in improving the quality of the beets, both as to sugar content and acreage tonnage. In 1885 the average sugar content in France was 7.83 per cent, as compared with 12 per cent in Germany. By the introduction of improved German seed, and the application of better methods of cultivation the French crop has averaged during the past decade 11 to 12 per cent.

Germany did not outrank France in production until 1878, since which time she has held the first place in the world's production of sugar beets, and ranks first in the volume of the export trade. In 1836 Germany had 122 beet-sugar factories which consumed 25,346 tons of beets for the production of 1,408 tons of sugar. The average sugar extrac-

tion during this year was only 5.5 per cent, as compared with 12.18 per cent in 1886. The per capita consumption in 1836 was only 4.4 pounds, which required an import of 51,527 tons of cane sugar. The next two decades witnessed a steady development of the industry, the production in 1856 being 87,359 tons, and the per capita consumption 7.14 pounds. Still the supply was inadequate and the price restrictive. The factory price in Magdeburg in 1856 was 9.4 cents per pound, as compared with 4.2 cents in 1886. In 1877 Germany had 258,000 acres of beets which produced 378,000 tons of sugar. Improvements in the methods of manufacture and the increased demand brought about a rapid increase in cultivation, as shown by the fact that the crop of 1886 yielded more than 1,000,000 tons of sugar. The amount of sugar consumed in Germany has increased with the increase of the sugar content, the increase in the percentage of extraction, the increase in acreage production, and with the decrease in the cost of production. In 1906 the per capita consumption was 41.18 pounds, the average sugar extraction 15.69 per cent, the cost of production 1.97 cents per pound, and the total production 2,223,521 tons.

Within the past quarter century the beet-growing industry has extended to all of the countries of Europe, and has been sufficiently successful in

Austria-Hungary, Russia, Roumania, and Scandinavia to make it recognized as a permanent source of wealth.

Very little has been done, even in an experimental way, toward the introduction of sugar beets into Asia, Africa, and South America. The general conditions in Asia are unsuited to an economic development of the industry, but certainly beets of satisfactory sugar content could be grown in many parts of the Asiatic highlands susceptible to irrigation, and throughout a large area in southern Siberia. The prospects are also considered favorable for a large development of the industry in Manchuria and a limited development in northern China. The profitable beet zone in Africa is unquestionably limited to a comparatively small area in southern Africa. At least limited areas in all the countries of South America are adapted to the cultivation of beets. Experimentation has already begun in the highland region of southeastern Brazil and in the temperate zone belt of Argentina.

The Government of the United States early interested itself in the investigation of the prospects for developing the beet-sugar industry in this country. The first successful experiment was made in 1838 by David Child of Massachusetts, who extracted six per cent of sugar. At this time

there was no separate Department of Agriculture, but the agricultural interests came under the supervision of the Commissioner of Patents. That the prospects were considered favorable may be judged by the following quotation from the report of the Committee on Agriculture: "From all the information which the committee have been able to obtain, they are induced to believe that no country in the world is better adapted for the production of sugar beets than most parts of the United States, whether we consider the soil, the climate, or the people." Following this report some of the states offered bounties on sugar from beets grown within the state. The bounty in Massachusetts was three cents per pound during a period of five years. Several private individuals were experimenting at this time on the growing of beets, but since little success was attained in the practical development of the industry, the enthusiasm soon waned, and was not renewed during the next twenty-five years.

The first well-defined efforts in the production of sugar beets for the manufacture of sugar were made in 1863 at Chatsworth, Ill. It was fortunate for this new period of experimentation that the agricultural interests of the Federal Government were detached from the Patent Office and placed in a special department under a Commis-

sioner of Agriculture. The Chatsworth enterprise, however, eventually failed, and it was not until 1870 that a permanent factory was established. In this year a factory was constructed at Alvarado, Cal., by two Germans, Bonesteel and Otto, which has been in continuous operation, excepting one year, since its construction.

The discouraging results from the early experiments conducted in the United States were due chiefly to the fact that the states engaged in experimenting were not adapted in soil and climate to the crop. The factories were also small, which made the cost of production too expensive. Whereas the countries of Europe had fostered the industry by the granting of subsidies and liberal bounties, the United States Government had offered no aid, brought to bear no material tariff protection until 1883, and no adequate protection until 1897.

The next successful factory was constructed in 1888 at Watsonville, Cal., by Claus Spreckels, the Hawaiian sugar king. During the first year of its operation 1,000 tons of refined sugar were manufactured. The Oxnard Brothers were the next to give factory impetus to the industry by the construction of a factory at Grand Island, Neb., in 1889; one at Norfolk, Neb., in 1891; and one at Chino, Cal., during the same year. From this we

see that the commercial production of beet sugar in the United States really dates from 1890, since only three factories had been established prior to that date, and they were of small capacity. The most significant legislative act was the Sugar Bounty Act of 1890, for the passage of which William McKinley labored so earnestly. It provided for a bounty of 2 cents per pound on domestic beet sugar, and was to be enforced for a period of fifteen years (1890–1905). This act was soon repealed, and the Wilson Act of 1894 did not afford adequate protection. The total output in 1892 was 13,000 tons, produced by six factories. The development was more rapid following the passage of the Dingley Act of 1897, according to which imported sugars were taxed as follows: refined sugar, $1.95 per 100 pounds; 96° sugar, $1.68 per 100 pounds, with a reduction of 3½ cents for each degree below 96, and an increase of 3½ cents for each degree above 96. During 1899 fourteen new factories were constructed. The total beet-sugar production of the United States in 1897 was 45,245 short tons (2,000 pounds), as compared with 218,406 tons in 1902. The area cultivated in 1902 was 216,400 acres, from which 1,895,812 tons of beets were sliced in forty-one factories. The development since 1902 has been of phenomenal rapidity.

TABLE IV

GROWTH OF BEET-SUGAR INDUSTRY IN THE UNITED STATES, 1902–1908

YEAR.	Beets Worked (short tons).	Price per Ton.	Total Value of Beets.
1902	1,895,812	$4.84	$9,175,730
1903	2,076,494	4.86	18,091,761
1904	2,071,539	4.95	10,254,018
1905	2,665,913	5.00	13,329,565
1906	4,236,112	5.10	21,604,171
1907	3,767,871	5.20	19,592,929
1908	3,414,891	5.35	18,269,667

The beet-sugar industry has made most rapid progress in the arid and semiarid States, California, Colorado, Utah, Arizona, Idaho, and Nebraska; and in Michigan and Minnesota. Since the passing of the Reclamation Act in 1903 irrigation projects have been pushed through with great activity, and the increase in the beet acreage under irrigation has kept pace. The superior adaptation of the crop to irrigation has already been noted. Since 1900 the total acreage in beets has increased more than 3-fold; but the acreage in Colorado has been increased in that period 125-fold—from 1,000 acres to 127,678 acres. Lands adapted to the growing of beets have increased in value disproportionately to the lands adapted to other branches of farming. It is estimated that irrigated sugar-beet

lands increased in value from 1900 to 1905 as follows: California, 42.5 per cent; Colorado, 118 per cent; and Utah, 36 per cent. Very little sugar-beet land in California can be purchased at $200 per acre.

The Government is laboring earnestly on the problem of seed improvement. The imported seeds deteriorate to a varying degree in the process of acclimatization. The prospect is favorable for the development of varieties which will be better suited to the United States beet belt. Encouraging success is also being attained in the direction of propagating a single-germ seed, which would greatly reduce the amount of hand labor now necessary in the early stages of cultivation.

Although the early failures in the development of the beet-sugar industry in the United States were largely due to geographic situation and crude methods of extraction, there are other considerations of increasing importance. Some have recently failed because the promoters overestimated the capacity of the community to produce beets. The expense of construction and equipment is so great and the harvesting season so short, that, unless the beet supply is ample to meet the demands of the factory, the profits of the working season are likely to be consumed by the losses of the idle season. It is also important to consider the adap-

tability of the region to other crops productive of larger money returns. The beet crop is now being rapidly supplanted in parts of Idaho and Colorado by fruits and vegetables. The maximum return on beets is $60 to $75 per acre, but if the land is peculiarly adapted to orchard or small fruits it will soon bring a net return of $200 to $600 per acre; or, if adapted to vegetables and convenient to good markets, trucking will be far more profitable than sugar beets. With the industrial development of the country must come gradual readjustments of crop distribution. The economic beet zone will gradually shift from the less profitable beet-growing localities, and become the more firmly established in situations having a maximum adaptation.

CHAPTER IX

THE BEET-SUGAR INDUSTRY IN THE UNITED STATES

The average summer temperature and the distribution of the annual rainfall are the controlling climatic factors which outline the profitable sugar-beet zone in the United States. The crop seems to mature most satisfactorily where the average temperature of June, July, and August is about 70° F. The Department of Agriculture designates a belt 100 miles in width on either side of this summer isothermal line as the economic beet-growing zone. (See frontispiece.) That this deduction is well founded is evidenced by the location of the territory now under cultivation. It is not to be understood that beets do not mature outside of this comparatively narrow belt, for they can be grown in practically any cultivatable part of the United States. Parts of Mississippi or Tennessee will yield as large a tonnage as corresponding areas in Idaho or Colorado, but the sugar content of the crop in the humid Southern States is from forty to sixty per

cent less than from an irrigated crop in the arid Western States. In addition to this prohibitory difference, the climatic conditions during the harvesting and milling season are such that great losses would be incurred.

The sugar content varies from year to year, being influenced by variations in the seasons, differ-

Field of Beets near Albuquerque, N. M.

ences in the method of cultivation, and changes in the quality of the seed. The margin of profit is determined by so many factors that it is difficult to say what constitutes the minimum sugar content permitting a profitable milling of the crop, but it

is generally conceded that under present competitive conditions the success of the enterprise is doubtful unless the average is as high as twelve per cent. If we may judge the future by the past, the zone will be much extended by improvements in breeding, cultivation, and manufacture. Were the potential beet area in the United States exploited as thoroughly as it has been in Germany, the production of this country would closely rival Germany. It is estimated by the Department of Agriculture that the United States has 274,000,000 acres adapted to the cultivation of beets, and that if this area were cultivated in four rotation crops, beets constituting one, the annual sugar produc-

TABLE V

SUGAR FACTS FROM THE BEET-GROWING STATES, 1908

STATES.	Number Factories.	Acreage.	Beet Tonnage (long tons).	Sugar Manufactured (pounds).	Percentage of Sugar in Beets.
Colorado	16	110,000	1,100,000	229,090,000	15.3
Michigan	16	81,500	570,500	148,900,000	17.11
California	9	55,500	550,000	147,950,000	17.9
Utah	5	28,600	229,000	48,000,000	16.3
Idaho	4	18,500	148,000	41,670,000	17.8
Wisconsin	4	17,900	161,000	32,500,000	15.0
Nebraska	1	17,500	122,500	23,500,000	.....
Kansas	1	12,000	111,000	23,310,000	.....
Ohio	1	6,000	48,000	9,950,000	.....
New York	1	4,300	38,700	7,900,000	.....
Washington	1	4,100	22,000	5,500,000	.....
Minnesota	1	4,000	23,000	4,650,000	.....
Oregon	1	3,400	21,000	4,360,000	.....
Montana	1	3,000	24,000	4,900,000	.....
Arizona	..	3,000	.....	.....	.....
Illinois	1	1,000	6,000	1,200,000	.....

tion would be 15,000,000 tons. There are now 400,000 acres in cultivation, which is more than double the acreage in 1901.

Colorado has almost one third of the total acreage, and yet the beet-sugar industry was prac-

FIELD OF BEETS NEAR ITHACA, MICH.

tically in its experimental stage in that State ten years ago. All of the factories except one have been constructed since 1901. The industry now constitutes the leading agricultural source of wealth in the State. Thirty-two thousand field laborers were required in 1908 to cultivate and harvest the crop, for which the laborers and farmers received $12,750,000.

Michigan is second in acreage, and second in output, and is the only large beet-growing State

having no irrigation. The industry has been subject to more fluctuations and vicissitudes in Michigan than in any other state, but has so adjusted itself to the economic conditions as to stand to-day on a sound and profitable basis.

The factory at Spreckels, Cal., has a daily capacity of 3,000 tons and is the largest beet-sugar factory in the United States. It is owned by the Spreckels Sugar Company, which is also the largest refiner of raw sugar on the Pacific Coast.

Utah and Idaho comprise a large contiguous sugar-beet area, and in the richness of the sugar

Factory of Utah-Idaho Sugar Company at Nampa, Idaho.

content these two states are only rivaled by California. The present sugar production within the states is four times the domestic consumption, and yet the capacity of the nine factories in operation

is considerably larger than the supply of beets from the 48,000 acres in cultivation.

The United States has sixty-three factories in operation, distributed among sixteen states. The average yield of beets per acre in the different states varies, but California, Colorado, Utah, and Wisconsin lead with an average of ten tons per acre.

The total production in 1908 was 500,000 tons of beet sugar, the estimated value of which at the factory was $45,000,000. This was more than double the output in 1904. We have already seen that the cane-sugar production during the same year was 347,000 tons. During the past decade the cane-sugar production increased about 10 per cent, while the beet-sugar production increased 1,200 per cent. To meet the home demand it was necessary to import in 1908 916,000 tons of raw sugar from Cuba, 453,000 tons from Hawaii, 185,000 tons from Porto Rico, 45,000 tons from the Philippines, and more than 350,000 tons from other sugar-producing countries. The total sugar import was valued at $133,000,000, which, coupled with the domestic sugar consumed, makes the present cost of sugar to the people of the United States about $1,000,000 per day. Practically all of the imported sugar is raw, and therefore purchased at little more than half the retail price of refined sugar. At the present rate of production and consumption, we are

Sugar Beets. This pile represents ten tons of sugar beets grown on two-fifths of an acre of land at the Experiment Station Farm, at Madison, Wis.

Twenty-three Hundred-pound Sacks of Granulated Sugar. This is the product of the ten tons of beets in the picture above. The University received a check for $44.32 from the Wisconsin Sugar Co. for this shipment. This is at the rate of $110.80 per acre.

only producing one-fifth of the sugar consumed, but have a sufficient acreage adapted to sugar cane and sugar beets to easily meet the home demand. The United States is consuming from twenty-two to twenty-five per cent of the total sugar production of the world, exclusive of India's crop, accurate statistics of which are not obtainable. The per capita consumption in the United States as compared with other countries is outlined in Table II.

The cost of producing either cane or beet sugar in the United States is somewhat higher than it is in the largest sugar-producing countries, because of the high rate of wages paid in this country, and because of the general economic conditions which are experienced in any industry in its early stages of development. The beet-sugar industry must be recognized as comparatively a new industry in this country. The average cost of producing cane sugar is estimated at $2\frac{1}{2}$ to 3 cents per pound, and the average cost of producing beet sugar is from 3 to $3\frac{1}{2}$ cents per pound. The absolute factory cost of production in Germany is estimated at 1.95 cents per pound by the most careful statistics obtainable. The average cost of field labor in Germany is from 50 to 70 cents per day, as compared with $1 to $1.50 in the United States. The cost in France differs but little from the cost

in Germany, the rate of wages being practically the same in the two countries. The wages of farm laborers and of unskilled factory laborers in Austria is from 15 to 30 cents per day, which enables her to produce sugar at less cost than any other beet-growing country, with the possible exception of Holland. Since 3½ cents per pound is about the average cost of making sugar in this country, this represents practically the amount of money which is paid to the farmer, the farm laborers, and the factory workers. About one half cent per pound is the amount paid out by the importers and refiners to the laborers on the imported raw sugar. The fact that most of the sugar imported is refined in the United States is not so significant, in the light of this comparison. On the basis of this estimate $167,000,000 more would have been distributed to American laboring constituents in 1907, if the United States had produced all the sugar consumed.

The average cost of growing beets varies considerably in the different states. California reports an average of $23 per acre; Utah, $32 per acre; Michigan, $34 per acre; and Nebraska, $28 to $34 per acre. The average yield of the beet-growing states is 7 to 10 tons per acre, and $5 is about the average price paid per ton. The producer, therefore, realizes an annual profit of $15 to $40 per

acre on the basis of the present price and the present acreage yield. In limited areas of superior adaptation and under good cultivation the yield is 20 tons per acre, which gives a profit of $50 to $60 per acre. The consideration of these figures leads to the conclusion that the growing of beets offers a fair profit and an increasing profit, because of the adaptability of beets as a rotation crop for a soil-conserving system of cultivation. The crop is subject to less risk than most of the crops which bring larger returns. It is drought resistant, and can be best matured by irrigation. Notwithstanding this, the beet crop cannot be expected to compete successfully on land which is highly adapted to fruits and vegetables. The prospect is that the factories will continue to pay higher prices for the beets both because the growers will demand it, and because the prosperity of the manufacturers will permit it, as the industry becomes more firmly established and the output increased. The average cost of beets in the continental countries of Europe was estimated at $5.75 per ton in 1908, and yet the grower of the beets produces them with labor which costs from forty to sixty per cent less than must be paid in the United States.

An improvement in the American method of contracting and paying for the crop is one of the most

needed reforms in connection with the beet-sugar industry. At various points in the beet-growing states the factories are experiencing great difficulty in obtaining a crop sufficiently large to satisfy the capacity of the factory. Some farmers are refusing outright to grow beets, while others accept contracts with serious doubting as to what they will realize on them. The greatest dissatisfaction on the part of the grower has arisen on the question of *tarcing*, which is the amount deducted from the field weight of the crop to counterbalance the losses through washing.

Another problem which confronts the factory owners is the prolonging of the harvesting period. Beet-sugar factories are expensive in construction and operation, and represent an investment of $300,000 to $1,500,000. The length of the milling campaign varies in different states from sixty to one hundred and twenty-five days, and in order to get a period of this duration, it is necessary to plant the crop with reference to a successive maturing by plots. The average duration in all of the states except Colorado, Utah, and Idaho is less than seventy-five days, or approximately one fifth to one sixth of the year, and during the remainder of the year the investment is idle and the factory force must seek employment elsewhere. The great loss and inconvenience entailed by this

method is obvious, and with the further development of the beet-sugar industry it will certainly be necessary that a larger proportion of the beet crop be siloed for preservation until they can be handled by the factories. This both increases the cost of production by $2.50 to $3 per acre, and incurs a slight deterioration in the beet, but the factories will ultimately see the economy of paying more for the crop to the end of extending the period of operation.

The factories of Michigan and California import raw cane sugar for refining during the non-milling season. No doubt this accounts in part for the prosperity of the Michigan manufacturers, in spite of the fact that the climatic conditions are less favorable both for maturing the beets and for milling the crop than exist in the arid and semiarid states.

There is much room for improvement in the methods of cultivation. The average tonnage yield under irrigation in this country is not as large as the average yield in Germany, France, and Belgium, without irrigation; and yet the average yield in this country would far exceed that of these countries if the same methods of cultivation were in vogue. This is as strikingly true in the yield realized on other crops. The average wheat yield in the United States in 1906 was 13.8 bushels per acre,

while during the same year the average in Austria was 17 bushels; in France, 19 bushels; and in Germany, 28 bushels. The European countries, with less fertile land but with more careful cultivation and more adequate fertilization, produced larger staple crops. The beet is not an exhaustive crop, and is well adapted for rotating with other marketable and profitable crops. The methods of cultivation are being rapidly improved, which becomes more urgent with the rise in the price of land and the closing in of competitive conditions. It is estimated that about seven per cent of the total acreage planted in beets is abandoned each year. This high percentage in itself shows room for much improvement, since most of it is attributable to inferior cultivation.

Although most of the United States factories are improved and economical types, we are not obtaining as satisfactory results in the extraction of the sugar as are obtained, particularly in Germany, France, and Belgium. The average per cent of raw sugar extracted in the United States in 1908 was 12.6 per cent, while the average in France was 12.6 (with lower average sugar content); in Belgium, 14.7 per cent; in Austria, 17.2 per cent; and in Germany, 17.5 per cent.

The benefits of the beet-sugar industry to communities are reflected in the industrial activities in

other lines, and in the standard of living of the laborers. The character of the cultivation re-

Thinning Beets.

First Cultivation after Thinning.

quired for producing the largest yield of beets is such as can only be supplied by intensive cultiva-

tion. Much of the work can be done with machinery, but the early cultivation and thinning must be done by hand and with the hoe.

The German peasants have the idea that they hoe sugar into the beets, and this is not far from the truth, since on the same quality soil the sugar content varies from ten to eighteen per cent, depending upon the methods of cultivation.

To obtain an adequate working force for the cultivation of an area to meet the demands of a large factory, it is necessary that the country be injected with a village life, so as to make accessible a large number of laborers for limited areas. It is evident, therefore, that beet growing affords a larger supporting capacity than the grain and forage crops. The factory, which is located in the midst of the community, also requires skilled laborers, all of which results in increasing the diversity of wants.

Vast changes have been wrought in the sugar-growing districts with reference to diversified production. The sugar-beet industry has especially stimulated the live-stock industry. Most of the land which is now utilized in the irrigated regions of the west for growing sugar beets was formerly used only as wild grazing land, and under that régime the methods were careless and the breeds indifferent. With the introduction of profitable

cultivation came the necessity of placing the live-stock industry on a different basis. The old native breeds were supplanted by imported stock from the Eastern and Central States and from European countries, and now the live-stock production is placed upon a more profitable basis. To illustrate: Instead of sheep being kept for the wool profit, they are kept primarily for the production of lambs, and the fleece of these highly bred varieties is so much larger than was obtained from the native stock that the wool increase more than covers the expense of maintenance.

The sugar-beet industry, in stimulating and encouraging the rotation of crops, is doing a service which is probably greater than any other from the standpoint of the ultimate individual and national prosperity. Wherever a large sugar factory is located, it devolves upon the management to supply to the community a well-trained agriculturist and a staff of capable assistants to travel over the producing areas, and in an educational way superintend the planting and production of the crops. They not only give their attention to the specific beet crop, but to the rotation crops under cultivation, which are of equal importance, since the profit of the beet crops of future years depend in a large measure on the conservation of soil fertility.

Diversified factory production is beginning to

spring up in many of the beet-growing regions. The conditions are becoming more favorable in the irrigated districts for the development and utilization of cheap water power. The raw products, such as wool, cotton, and lumber, are accessible; and it is only a question of time until local factories will supply the most important commodities consumed by the ever-increasing population. Diversified industrial activities always have the effect of increasing the general prosperity, which makes it but a step to the acquirement of better educational advantages. As a result, good schools and colleges are established to meet the educational needs of the people, while the factories and fields supply their physical wants.

From the standpoint of present economic conditions, it seems too sanguine to hope for the United States to become an exporter of sugar, but it is altogether plausible to hope that the domestic production will continue to increase at even a more rapid rate than it has in the past decade, which will mean that the next generation will be making their own sugar. On the basis of present cost we can scarcely hope to lower the price of refined sugar by becoming our own producers, since the average price of refined sugar in the United States does not give a wide margin above the absolute cost of factory production at the present scale of

wages. From the standpoint of distributed prosperity the reduction in the price of sugar from 5 cents to 4 cents per pound is not so desirable as to be independent of foreign supplies, which would mean the payment of more than $150,000,000 annually to American sugar-producing laborers. We do not, however, advocate the attempt to expand the domestic sugar industry with undue rapidity, believing that the better and more stable conditions will be conserved by a steady development, carrying with it improved methods both in cultivation and in manufacture. This will give time for perfecting the industry more than could possibly be achieved by any spasmodic development; and will at the same time permit the adjustment of the industry to its rightful place among the many competitive industries. Unless the future is entirely different from the past, the consumption will continue to increase, and the adaptations of the by-products will also become more varied and more valuable.

CHAPTER X

THE BEET-SUGAR INDUSTRY IN FOREIGN COUNTRIES

Until the middle of the last century the world's sugar supply came chiefly from cane-growing countries, the most important of which were the islands of the West Indies, the East Indies, Brazil, and Louisiana. In 1825 the total beet-sugar production in Europe was only 5,000 tons, but in 1850 it was 190,000 tons. Since 1850 the beet-sugar industry has increased with phenomenal rapidity, and the cane-sugar industry has been steadily expanded, with the exception of a few island producers. At this time the world's supply is almost equally divided between cane and beets (49.7 per cent beet and 50.3 per cent cane), but the beet-sugar production is increasing far more rapidly than cane. In 1890, 43 per cent of the world's production was beet and 57 per cent cane. So far, both sources of sugar have been no more than able to meet the natural demand. The competition, however, is becoming keener each year, and is

destined to cause marked shifting in the fields of production for the maintenance of an economic balance.

In 1908, 4,860,000 acres were cultivated in beets in Europe, which produced 44,626,000 tons of beets, giving a total beet sugar production of 7,041,000 tons. It seems certain that a much larger area of the earth's surface is adapted to an economic production of beets than to cane. In the consideration of the production of the two kinds of sugar the fact that the beet matures best in the temperate zone, while the cane is indigenous to the tropics, militates strongly in favor of beet production. The tropics not only offer conditions which are not conducive to diligent labor and thorough cultivation, but occasion such a luxuriant growth of grass and weeds as to greatly complicate the problem of cane cultivation.

The cultivation of sugar beets has not developed to a status of commercial importance except in the continental countries of Europe and in the United States.

GERMANY

Germany easily ranks first among the beet-growing countries, producing almost one third of the total world's supply. Her production in 1907 was 2,223,521 metric tons (2,204 pounds), of which

1,098,835 were exported. For producing this enormous total 1,110,000 acres of beets were cultivated, which gave an average of 12.7 tons of beets per acre, and 1.99 tons of sugar per acre.

With the increased production in Germany has come a corresponding increase in consumption. In 1886 Germany produced 1,012,000 tons of sugar, and the average per capita consumption in that year was 16.5 pounds. The above figures show that from 1886 to 1907 the production was more than doubled, and as the per capita consumption in 1907 was 41.1 pounds, it is obvious that the rate of consumption increased somewhat more rapidly than the rate of production.

Considerable changes are in progress in Germany with reference to the centers of beet production, the methods of cultivation, and the methods of manufacture. During the past decade there has been much reorganization, which has resulted in the improvement of factory equipment and the elimination of inferior plants. In 1887, 400 plants were in operation, while in 1909 there were 358.

The beet-sugar industry of Germany is confined chiefly to Saxony, Brandenburg, East Prussia, and West Prussia. The region around Magdeburg has long been noted for its industry, and Magdeburg is still the largest manufacturing center; but there is

KLEIN WANZLEBEN SUGAR-BEET FACTORY. (Germany.)

in progress a rapid development of the beet-sugar industry in both East and West Prussia.

The German producers are aided by a special government bounty on all domestic sugar produced, and an additional bounty on all sugar exported.

Although Germany can produce beet sugar at less cost than the United States—the cost in Germany being a little less than 2 cents per pound, while the cost in the United States is probably not less than 3 cents per pound—yet the retail price of sugar to the German consumer is higher than the retail price in this country, on account of the consumption tax levied by the government.

AUSTRIA-HUNGARY

Austria-Hungary is making substantial progress in the development of the beet-sugar industry. In 1908, 816,432 acres were in cultivation, which produced 1,409,000 tons of sugar. The total amount consumed in the country was 556,000 tons, this being less than 40 per cent of the total production. This gives a per capita consumption of about 24 pounds. The United Kingdom purchased 90 per cent of the total sugar exported. The expansion of the industry may be judged from the fact that the export in 1908 was 15.5 per cent larger than in

1907. The consumption tax in Austria-Hungary is 3.4 cents per pound, and the average retail price of sugar in 1908 was 7.4 cents per pound.

There are 204 sugar factories in the Empire, distributed as follows: 119 in Bohemia, 61 in Moravia and Silesia, and 24 in Hungary. Aussig, on the Elbe, is the most important port for the exportation of sugar by water.

The average cost of production in Austria is estimated at 1.85 cents per pound, which is considerably below the cost of production in the other large beet-sugar-producing countries. This is because of the low wages which prevail throughout the country, which vary from 15 to 30 cents per day in Austria, and 40 to 60 cents per day in Hungary.

The Germans have had a great influence on the development of the sugar industry in Austria-Hungary, and the methods of manufacture in vogue are for the most part patterned after the most approved types of Germany.

RUSSIA

The beet-sugar industry has developed in Russia with such rapidity during the past two decades as to give her first place in acreage, and third in sugar production. From the standpoint of soil and climatic adaptation, this country has the pos-

sibility of even exceeding Germany in production, and thereby become the largest beet-sugar-producing country. The total production in 1908 was 1,403,000 tons of sugar from 1,360,000 acres. The Russian people, being light consumers of sugar—17.6 pounds per capita—have a considerable surplus for export. In 1850 the per capita consumption in Russia was one half pound, which was less than that of any other country of Europe. It is evident, therefore, that the consumption has increased at a phenomenal rate since the introduction of the beet-sugar industry into that country. Although the cost of unskilled labor in Russia is low, the methods of cultivation and manufacture are so inferior that the cost of producing sugar in that country is estimated at 2.3 cents per pound, which is greater than in any other beet-growing country except the United States. Russia has a consumption tax of 2 cents per pound, and the cost to the consumer is from 8 to 10 cents per pound for lump sugar, which is more generally used in continental Europe than granulated sugar.

The growing of beets is now limited almost exclusively to the fertile Black Belt country of Eastern Russia, and Kieff is the center of the refining industry.

The Russian surplus is exported to Finland, Tur-

key, Germany, England, Persia, Afghanistan, and other Asiatic countries.

FRANCE

Although France has not kept pace with Germany, Austria-Hungary, and Russia in the expansion of the beet-sugar industry, there has been in progress in recent years a steady improvement in the methods of cultivation and manufacture. There has been a gradual decrease in the number of factories, and a corresponding enlargement and improvement of the factory equipment. In 1883 France had 483 factories in operation, which produced 406,000 tons of sugar. In 1908 there was a total of 251 factories, which produced 719,900 tons of sugar. Although the quality of the beet has been improved greatly, France has increased her output during the past two decades less than any other beet-growing country. The domestic consumption in 1908 was 596,243 tons, making a per capita consumption of 36 pounds, as compared with 6.5 pounds in 1850. The retail price of sugar in Paris in 1908 was $6\frac{1}{2}$ to 7 cents per pound.

The growing of beets for the manufacture of alcohol is an important industry in France. The output from this source in 1907 was 30,262,000 gallons. Much of this alcohol is denatured and

used for heating, lighting, varnish manufacture, the manufacture of ether, and explosives. The areas cultivated in beets are confined chiefly to the plains of Flanders, Picardy, Brie, Beauce, and Limagne.

BELGIUM

On account of various limitations, the beet industry is practically stationary in Belgium. The production in 1907–8 was 235,000 tons, which was less than the production in the two preceding years, and about equivalent to the average annual production during the past six years. The quality of the beets grown is good and the tonnage large, the sugar content of the 1908 crop being 14.7 per cent, and the yield 12.5 tons per acre, which was a higher tonnage average than made by any other beet-growing country. The consumption tax is 2 cents per pound, and the per capita consumption 24.5 pounds. The average price of sugar in Brussels is $5\frac{1}{3}$ cents per pound, which is a lower price than exists in any other European country except the United Kingdom. The price of sugar in Belgium was $3\frac{1}{4}$ cents higher per pound prior to the Brussels sugar convention.

Antwerp has long figured prominently as a sugar-refining center for Europe, and is still the important refining center in Belgium, both for the

domestic-sugar and the raw-sugar import from cane-growing countries.

HOLLAND

The domestic production of beet sugar and the colonial production of cane sugar are exploited vigorously and economically by the Dutch. One hundred and twenty thousand acres are cultivated in beets, which give a production of 173,000 tons of sugar. The factories are large and well equipped, as evidenced by the fact that the total crop is handled by twenty-eight plants. Wages are low, which, combined with economy of manufacture, enables Holland to produce sugar at 1.5 to 1.6 cents per pound. The importation of raw sugar is large, making possible a large exportation of refined sugar, which in 1906 aggregated 161,596 tons. The per capita consumption is 41.5 pounds, which is 70 per cent larger than the consumption in Belgium, and yet the retail price of sugar in Holland is more than 60 per cent higher than in Belgium. The average price in Amsterdam from 1904 to 1907 was 9.4 cents per pound, attributable to the high consumption tax of 4.6 cents per pound.

ITALY

Although only limited areas of Italy are adapted to beet culture, the industry is advancing steadily.

In 1908, 150,223 tons of sugar were manufactured from a crop of 108,725 acres. The average cost of production is estimated at 3 cents per pound. The consumption tax in Italy is 5.7 cents per pound, and the retail price of sugar 13 to 14 cents per pound. The tax is higher than in any other country of Europe, and the price to the consumer higher. The prohibitory price, the poverty of the peasant peoples, and the prevailing foodstuffs make the per capita consumption in Italy 8.3 pounds, which is lower than in any other sugar-producing country, except Bulgaria, Greece, and Servia.

SWEDEN

The beet-sugar industry has developed rapidly in Sweden, and now stands second only to the dairy industry in the list of agricultural productions. Eighty-one thousand acres are in cultivation, and the production in 1908 was 109,500 tons, which about meets the home demand, the total import of sugar and molasses in 1908 being only $16,654. The consumption is 46.8 pounds per capita, which is 65 per cent above the general average for all Europe. The cultivation is concentrated in Scania, and the most important manufacturing centers are Helsingborg, Kjeflinge, and

Karpalund. The average price in Stockholm is 7½ cents per pound.

SPAIN

Beets cannot be grown successfully in Spain except in the higher valleys and on the plateaus which either have an average rainfall or are subject to irrigation. In contrast to the countries discussed, the industry in Spain is declining, having in 1908 74,131 acres in cultivation, as compared with 98,000 in 1907, and 82,668 in 1906. The production in 1908 was 106,000 tons, which was almost equal to the consumption.

DENMARK

Production in Denmark is practically stationary, the acreage in 1908 being 37,065, and in 1906 37,559. The production in 1908 was 52,700 tons. The per capita consumption is 73.6 pounds, which makes the people of Denmark the heaviest European consumers of sugar, excepting the United Kingdom. Beets are cultivated chiefly on the islands of this small kingdom.

GREAT BRITAIN

The British Isles have just taken the first steps toward the development of the beet-sugar indus-

try in the home country. The first factory is being constructed in the western part of Lincolnshire, with a capital of $450,000. Already 2,000 acres are under contract for supplying beets during the first season of the factory's operation. The contract price for the beets from this acreage is $4.38 per ton. For several years the British Government has been making some experiments on the possibilities of the beet-sugar industry in the different islands, and the prospects seem sufficiently favorable for a commercial beginning. The success of the undertaking depends upon a number of conditions which are so different from those to be found in the other beet-growing countries that no final opinion can be given until the industry has progressed further. It is hoped by the more sanguine advocates that the growing of beets may become an important innovation in the agricultural system and economy. In Germany, which is the largest beet-growing country, the economic and social conditions are so different from those existing in Great Britain, that it is difficult to discuss the possibilities by a comparison. In Germany the beets are largely produced on small farms, but the landlord system of the United Kingdom makes a different system of production and control necessary. More than one half of the land of England and Wales is owned by 2,500 persons, and three

fourths of it is owned by 38,200. Under this system the labor conditions have become more unfavorable in recent years, largely due to the continued increase of the city population at the expense of the rural population and prosperity. In 1891 28.3 per cent of the total population was rural, while in 1901 only 23 per cent was rural. Any change in the agricultural system which would lead to the cultivation and control of smaller areas would be a great national benefit. It will take something of this order to turn the tide of emigration, which has already assumed alarming proportions. In 1894 the emigrants out of the United Kingdom represented a proportion of 9 to 10,000, but in 1909 the proportion of those leaving was 40 to 10,000.

OTHER COUNTRIES

Small quantities of beet sugar are produced in Roumania (12,500 tons), Switzerland (3,370 tons), Bulgaria (3,080 tons), Greece (2,080 tons), Servia, Turkey, and Canada (12,500 tons). In all of these countries, except Canada, the price of sugar is high, and the per capita consumption from 8 to 12 pounds.

The Canadian sugar industry is not making satisfactory progress, and the home demand is filled

largely by imports, which in 1907 were valued at $11,411,000, distributed as follows: from the United States, $258,000; from Great Britain, $1,233,000; and from all other countries, $9,920,000.

CHAPTER XI

MANUFACTURE OF SUGAR

CANE

Milling.—Cane was used as a food many centuries before the art of extracting the juice by machinery and separating the sugar was discovered. The crushing was effected by the teeth, and the juice extracted by the suction of the mouth. Where the stalks were too large to be handled by the human masticating machine they were pounded with mallets or clubs until reduced to a convenient size and form. This primitive method is still in vogue among the tribes of Central Africa, and the sugar cane in stalk is one of the common articles of exchange and trade.

The pioneer methods of milling in the cane-growing countries of the world were of close resemblance. The first crushers consisted of wooden rollers, usually vertical, and articulated by the use of wooden cogs and pinioned cylinder shafts. Naturally they were crude and inefficient, twenty-

five per cent being the average amount of juice extracted when operated by hand power. Although sugar-making had been a recognized industry for more than a century in the tropical lands

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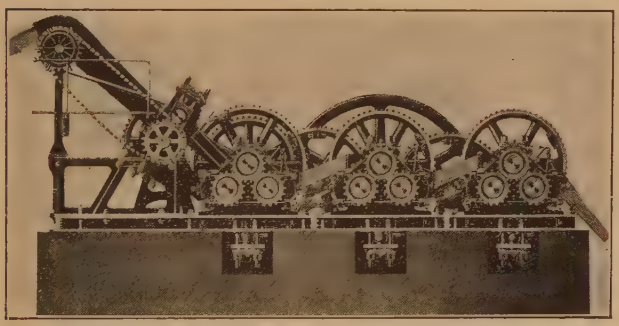
THE OLD WAY OF EXTRACTION.

of the New World before it was successfully launched in the American colonies, the old vertical wooden roller was the machine set up for

The Primitive Wooden Rollers.

More Efficient Power and Rollers.

"working up" the sugar crop. Soon the wooden rollers were supplanted by vertical cast-iron rollers, which in construction and manipulation differed but little from the vertical wooden rollers. This represented a distinct advance in the economy of sugar production, increasing the total extraction from twenty-five per cent of the juice to more than forty per cent. The next advance was marked



NINE-ROLLER MILL WITH A THREE-ROLLER CRUSHER.
(Fulton Iron Works.)

by the introduction of steam power, increase in the size of rollers, and the introduction of the horizontal type. These raised the efficiency of extraction to sixty-five per cent. For some years steel rollers have been used exclusively in the larger mills, and the rollers have increased from three to nine. Many of the mills have shredders or corrugated crushers, through which the cane is passed before

conveying to the smooth rollers. The cane is prepared in this way for an equalized pressure, and in mills of the most approved types 80 to 90 per cent of the juice is extracted. In addition to the mechanical improvement in construction has been added the economical benefits of partial diffusion, which consists of saturating the bagasse with water and passing it through the mill several times consecutively.

The capacity of the mill is determined by the size and velocity of the rollers. A maximum velocity does not result in a maximum extraction. Regularity of feeding is one of the most important factors in determining the efficiency of a mill, as the extraction must be imperfect in all zones of diminished pressure.

The diffusion method, universally used in separating the sugar content from beets, is being successfully applied to cane in a few plants. It has not, however, advanced beyond the experimental stages. Under this method the crushing process is supplanted by cutting the cane diagonally into small chips by means of revolving knives, and the chips are carried by automatic hoists into the diffusion batteries, which do not differ from those used in beet factories except in shape.

Reduction and Separation.—The old method was known as the "open-kettle" process. The

equipment for this was simple and cheap, and correspondingly slow and inefficient. The juice was conveyed from the mill through a spout into two or more square wooden vats stationed in the mill room, which adjoined the boiling room. A wire sieve was fastened to the corner of the vat to strain

Primitive Sugar House.

out the pieces of stalk and pith. Milk of lime was then added to the cane juice to the point of neutrality, after which it was ready to be conveyed to the boiling room. The boiling room was equipped with four kettles in a line, to which the following names were applied: *grande* (largest), *flambeau*, *syrop*, and *battery*. These kettles were

set in solid masonry and separated by a distance of about fourteen inches. The furnace was under the battery, the last in the series, and the one in which the final reduction must be made to a standard specific gravity. The furnace was maintained at as uniform temperature as possible from the beginning of the season until the close. During evaporation all the kettles were kept boiling except the grande. The milk-of-lime treated juice was conveyed to the grande and the boiling started in it. The lime caused the coagulation of the albuminous constituents which rose to the top in the form of a green scum. When the scum thickened sufficiently to break marked the stage for skimming. This stage of the process was known in sugar-house parlance as *yawing*. The coagulation and clarification were effected in ten to twelve minutes, after which the juice was transferred to the flambeau. Here an additional scum was formed from impurities which had escaped in the grande. If the proper amount of lime has been added the juice enters the flambeau almost transparent and of a pale yellowish color. If too much has been added it is easily detected by the alkaline smell and a reddish color, while an inadequate supply would be evidenced by the scum adhering to the sides of the grande and the flambeau. In the last kettle, the battery, the boiling continued until

the sirup showed a consistency for granulation—for being "struck," in the words of the sugar makers. This was, and is now, the most critical point in the whole process of sugar manufacture. A storage reservoir was provided adjacent to the battery for receiving the discharge in the shortest time possible. From the reservoir the sirup flowed through channels into coolers for granulation. These granulation tanks were constructed of wood, six to seven feet in length, four to five feet in width, and twelve to fourteen inches in depth. As soon as transferred to the granulaters the sirup was thoroughly stirred with a large spoon to reduce it to a uniform consistency. When a thin crust of crystals began to form on top, the stirring operation was repeated to scatter the crystals regularly through the sirup, which acted as centers of activity in the continued granulation. The crystallization of one charge required from six to fourteen hours.

Potting was the last operation in the "open-kettle" process, which consisted of the removal of the sugary mass from the coolers to hogsheads. The adhering molasses ran through holes in the bottom of hogsheads into the molasses cistern over which the hogsheads were placed in rows. This part of the process took from three to six weeks. The separation of the molasses from the raw sugar was

in some places accomplished by placing the boiled-down sirup in conical earthen molds. After the crystallization had progressed through the mass the hole in the apex of the mold was opened and the exposed top of the sugar then covered with moist clay. The moisture from the clay percolated through the sugar mass, driving the molasses before it. On removal from the mold the apex end, which still contained a large amount of sirup, was drawn off, and the remaining yellow loaf of sugar was ready for the mold. This method is in vogue in many parts of China to-day.

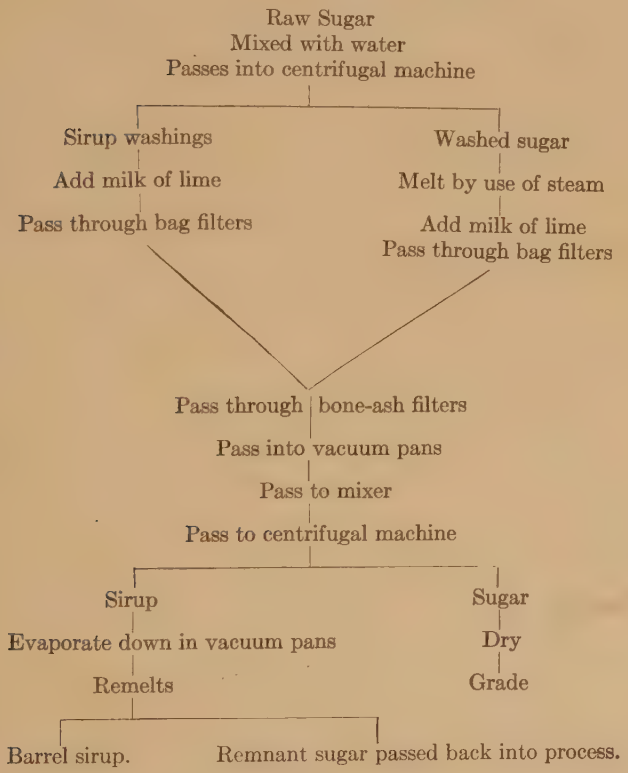
The old method of refining raw sugar was to dissolve it in lime water, add bullocks' blood in the proportion of 10 gallons to 6,000 pounds of sugar, and heat. The impurities were absorbed by the coagulating blood. Animal charcoal, which has a high affinity for coloring matter, was introduced in the United States in 1833, and this is now one of the important purifying agents in the refineries.

It is now customary to use sulphurous-acid gas or bisulphite of lime prior to treating the cane juice with lime. It serves the purpose of disinfecting the solution, and assists in bleaching and clarification. The purification of cane juice is effected more easily than in the case of beets, since it neither requires carbonatation nor an excess of

lime. If the sugar content is removed from the cane by diffusion it is only necessary to add a small quantity of lime and bring the solution to boiling.

TABLE VI

SHOWING STAGES IN REFINING RAW SUGAR



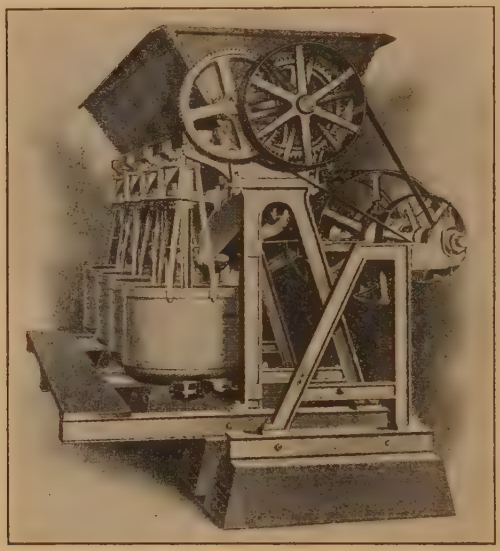
Modern Refining.—It has always been characteristic of the cane-sugar industry that the refining centers are remote from the sources of raw-sugar production. This finds its explanation in the fact that most of the cane is grown in the tropics, where the climate is hostile to the white man, making laborers inefficient and skilled labor difficult to obtain. These regions are also remote from the centers of largest consumption, and in most cases remote from fuel supplies. The chief exploiters of the sugar industry have always resided in the temperate zone, and it is but natural that as much of the production as possible has been shifted to their respective native countries, where the economic conditions for manufacturing are far more favorable. By shipping the product as raw sugar the transportation problem is also simplified, since it is susceptible to concentration in bulk in storage and shipping, which would be entirely impracticable for the refined product. New York, Philadelphia, and Baltimore became the refining centers for the imported raw sugars in the eighteenth century. It must be admitted that in the United States improvements in methods of refining increased more rapidly than improvements in the milling methods in the cane-growing states.

The raw sugars differ widely in chemical and physical properties, depending upon the grade and

the producing country. Its classified constituents are cane sugar, fruit sugar, soluble salts, insoluble salts, water, and extractives or coloring matter. The cane and fruit sugar determine the sugar yield, but the expense of refining is determined by the nonsugar constituents present. The raw sugars are first sampled with reference to grade, and mixed accordingly. In this way the approximate yield is predetermined by taking inventory of the producing parts.

The stages in the refining of raw cane sugar are so similar to those of the beet-sugar factory that the description of a typical refinery will be brief. The raw sugar is first mixed with water and passed into the centrifugal machine, in which the sugar is both washed and separated from the sirup content. The washed sugar is placed in the melters, in which the melting is either performed by the contact of live steam or by the melting pan being surrounded by steam coils (steam jacket). To this resultant sirup from the remelts milk of lime is added to the point of neutrality, at which the lime combines with the coloring and gummy elements contained to produce a flocculent precipitate. From the melters the sirup is pumped into tanks in the *blow-up* room. The sirup washing is here treated with milk of lime and passed through bag filters, after which it is ready to be mixed with

the molasses from the melted, washed sugar, and conveyed to the bone-ash filters. The sirup solution is decolorized by passing through the bone-ash



Centrifugal Machine.

or animal charcoal filters. The sirup is transferred to these charcoal cisterns at a temperature of 180° F., and the charcoal is kept at a temperature of 150° to 160° F. The clear sirup from the charcoal filters is now boiled in vacuum pans, boiled rapidly but under slight vacuum. In the vacuum pan the boiled mass takes a decidedly crys-

talline condition. When ready to be discharged the mass (mass-cuite) is dropped by means of a valve in the vacuum pan into the reheater or mixer, in which a temperature for maximum crystallization is maintained. From the mixers it is

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VACUUM PAN.

passed into the centrifugal machines for the final separation of remnant molasses. The sugar is trans-

ferred to the drying drums, which are equipped with sieves of different size for separating the crystals with reference to marketable grades. The sirup from the last stage of centrifugal separation is evaporated down in vacuum pans the second time. The resultant sugar is known as remelts, and is passed back into the process. The final molasses product is boiled with some fresh sirup until reduced to a purity of forty-five per cent, at which stage it is ready for the barrel.

BEETS

The harvesting of the beets consists of pulling them from the earth, removing the top by cutting off the crown of the root, and transporting to the factory. The pulling is done by hand and by specially adapted plows called "pullers." The topping is done by hand with a large topping knife or corn knife. If the cultivation has been shallow the beets grow out of ground, making heavy topping necessary. The beets are hauled on wagons to local loading points on the railroad. In many beet-growing communities the wagons are assembled into trains and moved by traction engines of thirty to sixty horse power. In loading into cars the beets are dumped from the wagons on an inclined grate which permits the dirt to fall through.

The cars on arrival at the factories are unloaded into storage bins or siloes.

It is essential that the beets be cleansed of all adhering earth, stones, straw, wood, and small

Loading Sugar Beets for the Factory.

roots. This is accomplished by various washing devices. A quarter of a century ago the revolving drum with perforations was the most common,

The beets were simply carried into this large drum, which, on being filled with water, was set in motion. This method, however, was inefficient and

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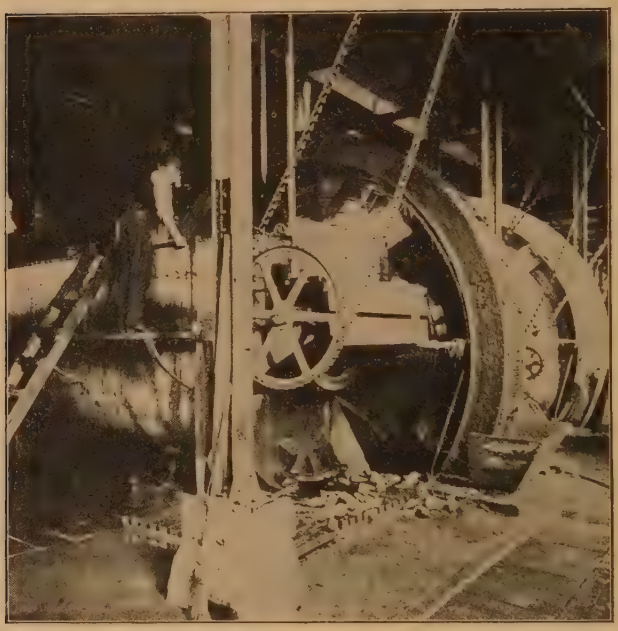
BEETS STORED IN SHEDS WITH V-SHAPED BINS HAVING CANALS UNDERNEATH TO CARRY THEM TO WASHING DRUM.

has been supplanted entirely both in Europe and in the United States. The most approved type of washing consists of the transfer of the beets from

the storage bins into a flume of varying length, through which water is flowing rapidly. This hydraulic carrier conveys the beets rapidly to large cylindrical troughs, which are equipped with a series of revolving wooden blades, so set as to keep the beets individually in motion, and force them persistently toward the end of the trough receiving the clear water. From this they pass into a stone-removing machine, the simplest type of which is a large tank in which revolve steel blades so set as not to reach the bottom. The water moves so rapidly through this tank as to keep the beets afloat, and the friction from the revolving blades, the water, and the beets removes effectively the foreign material, which drops to the bottom and is not disturbed by the blades.

In the United States no separate process is used for drying the beets as they come from the washer. In certain countries, like France, which levy a tax on the raw material instead of the finished sugar product, it is quite necessary to dry the beets before transferring them to the scales. This is usually done by passing them on to a metallic sieve slightly inclined, sixteen to twenty feet in length, which is equipped with a double-shaker motion. Passing slowly over this sieve the water is drawn from the beet, and any remaining portions of adhering foreign matter is likely to be removed. The

drying sieve connects with an elevator carrier, which conveys the beets to the weighing room situated in the top of the factory.



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WASHING THE BEETS WITH REVOLVING BRUSHES TO REMOVE DIRT AND SAND.—BEET-SUGAR INDUSTRY, CANADA.

All factories are equipped with automatic scales, which dump the load when a certain weight has been received. It is convenient and economical to

have the weighing room near the top of the factory so as to facilitate the further journey of the beets by gravity.

The next stage is the cutting of the beets preparatory to the sugar extraction. Prior to the general adoption of the diffusion process it was necessary to pulp the beets, but since the extraction of the juice by pressing the pulp was so wasteful and inefficient as to be entirely abandoned, we shall not consume the space in describing the process. The end to be attained under the present system is to slice the beets in such a way as to permit the largest surface contact of the individual pieces, called "cossettes," and of such shape and size as to enable each piece in the presence of water to maintain its identity. It is obvious, therefore, that if the beets were cut in squares that the pieces would fit so closely together as to prevent the object aimed at. The most approved method of slicing is to cut the beets by a multitude of curved knife blades, fitted on to a circular horizontal plate, which revolves rapidly around a vertical shaft. It may be said that a great variety of shapes result from the same slicing machine, and from the different models in use, but in all of them the policy of obtaining thin, irregular pieces is adhered to.

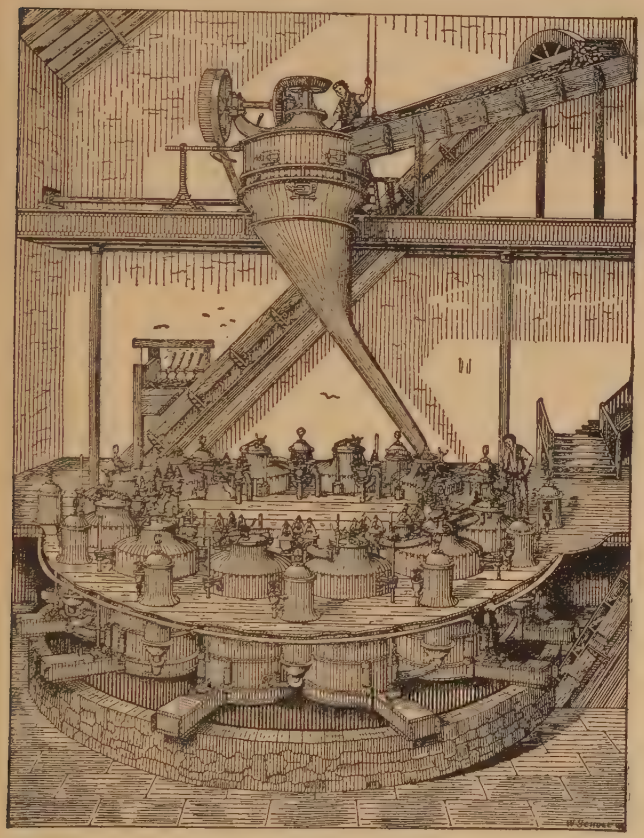
Mathieu de Dombasle introduced a maceration

process for the extraction of the juice from beets without pulping, rasping, or grating. The beets were cut into thin slices by a rotary machine, after which they were carried through a series of tanks containing hot water. The handicap to this process was that the dilution with the water made granulation difficult, and it was also subject to easy fermentation. It did not come into extensive use, and little progress was made until 1849, when Rousseau, Perier, Pozzoz, and Jelinek (of Austria) perfected the *double carbonatation* process, which was the greatest achievement toward placing the manufacture of beet sugar on an economic basis. This made the diffusion process practicable, and Seelowitz, an Austrian sugar manufacturer, further improved the process in its economy of operation.

The principle of diffusion is simple, in that it only involves the abstracting of the saccharine juice from the beet by the water contact, which starts up an exchange (osmosis) through the partition wall (cellulose) of the vegetable cells of the water without for the sugar juice within.

A diffusion battery consists of a series of cylindrical vessels which communicate with each other by pipes, so arranged that the juice issuing from the bottom of one diffuser flows into the top of the next. These tanks are equipped with a trapdoor

for charging with fresh beet slices, and a bottom door through which the exhausted beet slices are discharged. As the juice is passed from one dif-



Diffusion Battery.

fuser to the next it becomes of greater density, until ultimately it will have acquired a density approximately equal to the undiluted beet juice, at which point the osmotic action practically ceases, indicating that the extraction is completed. One of the great advantages of the diffusion process is that very small quantities of the vegetable albumen and gums pass through the cell walls into the water solution. Heat facilitates the abstraction, so that the cells of the diffusion batteries are kept at a temperature of 158° to 176° F.

The next step is to remove the diffusion liquors from the pulp by specially designed presses, which are so constructed as to give a slow application of pressure and as to cause a minimum bruising of the "cossettes."

Evaporation.—Raw beet juice cannot be evaporated on account of the pectic and albuminoid impurities contained, which convert the fluid into a gelatinous mass by continued heating. These impurities are largely removed by adding 1.5 to 3 per cent of milk of lime to the juice, heating, and the passing of carbon dioxide through the limed solution. This method is known as the *carbonatation process* or the *Jelinek process.* The heating of the limed solution causes the coagulation and precipitation of most of the impurities, and the injection of the carbon dioxide gas brings into solu-

tion the sugar which has combined with the lime. The solution at this stage is forwarded to the filter presses, and after filtering the carbonatation is repeated by adding 0.002 to 0.010 part of lime, and carbon dioxide gas to the point of saturating the lime. The solution is heated to boiling, which is effected by a coil of steam-conveying pipe. The last treatment of purification preparatory for the evaporators is to charge the solution with sulphur dioxide gas, which, by removing more lime and other impurities, leaves the juice of light yellow color.

The old expensive method of evaporating in open pans over a naked fire has been entirely discarded in all beet factories, and is in use in but few places in the world in the reduction of cane juice. The invention of the vacuum pan in the first decade of the nineteenth century was the first marked step of improvement in the method of evaporation. The efficiency and economy of reduction was still further perfected about the middle of the century by the introduction of the multiple-effect evaporators, which consist of a series of pans so connected as to result in a progressively higher vacuum. In this system the exhaust steam of the engine as well as virgin steam is utilized for heating the first pans, and the evolved steam from the evaporating juices is con-

ducted to the next cylinder to continue the process of which it constitutes a part. In the multiple-effect evaporators eighty to eighty-five per cent of the water contained in the diffusion liquor is removed in the form of steam. The heating in the evaporators brings the sirup to a specific gravity of 1.2 to 1.25. It is then conveyed to tanks for treatment with lime, phosphoric acid, and soda, for the removal of the remaining impurities, and is again charged with sulphur dioxide for bleaching. The next stage is to pass it into a vacuum pan called the *strike pan*, in which it is further evaporated to the point of crystallization. Much skill must be exercised at this stage both in the boiling and in the addition of fresh thinner sirup to the pan to regulate the growth of the crystals, or the *sugar grain*. Boiling is continued until only five or six per cent of water remains. The sugar mass is now known as mass-cuite. It contains a varying amount of molasses enveloping the crystals or grains. To obtain the largest yield a high vacuum is maintained which results in soft sugars, but a lower vacuum must be employed in producing granulated sugars.

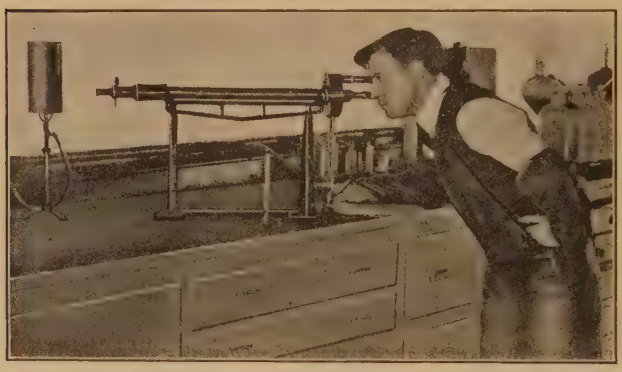
The molasses is separated from the sugar by whirling in centrifugal machines, which change the color of the mass-cuite from brown to light yellow. Centrifugal machines were first used successfully in 1860. The sugar (" first sugar ") is

conveyed to storage bins, and the molasses is carried back to the vacuum pan for boiling down to a mass-cuite. The resultant "second sugar" is dark, and must be dissolved in water and boiled with juice from the evaporator to convert it into white sugar. The molasses from this evaporation is either utilized as a by-product, or treated by the *osmose* process for the removal of the sugar. Since granulated sugar is ninety-nine and one half to ninety-nine and three fourths per cent pure, the molasses contains all of the remaining impurities from the cane juice which have not been removed in the purification processes. These impurities, the most important of which are the potash salts, will not permit the sugar of the molasses to crystallize by further evaporation. If, however, a series of frames covered by tightly stretched parchment paper be fitted together side by side and the heated molasses given access to one side of the parchment while hot water is placed in contact with the other side, there starts up an exchange between these two liquids of different densities. A part of the potash salts leaves the molasses, passes through the parchment and enters the water and some of the water comes through to take the place of the deserting impurities. The molasses comes out diluted but freed of some impurities. By evaporation a certain amount of brown sugar

is obtained, and in some factories this process is repeated two or three times, leaving a final molasses by-product so impure as to be only fit for fertilizer and stock food.

Drying is effected either by placing the sugar in heated drums, or by spreading out on floors. The motion which accompanies the drying period breaks up the crystals, so that this is called the *granulation* stage.

The amount of sugar present in any solution is readily determined by the use of the polariscope.



READING THE PER CENT SUGAR WITH THE POLARISCOPE.

Though this method of determination does not give absolutely correct estimates of the sugar content it is sufficiently accurate for most practical purposes.

The different grades of commercial sugar are obtained by different methods of washing and granulation. For obtaining the extra white grade, it is necessary to wash the sugar with steam, which causes the loss of a certain amount of sugar by dissolving it and passing it into the molasses drain-off. If soft white sugar is desired, the process is stopped after passing through the centrifugals. The granulated grades are obtained by controlling the crystallization in the granulators, and by sieve grading. The cube and tablet grades are but the granulated sugars shaped in molds, and the soft white and yellow sugars of the market are partially refined grades.

CHAPTER XII

SIRUPS

Sirup and molasses are words which are used synonymously by many persons, but in the character and origin of the commodities they are to be distinguished. Sirup is an original product from sugar cane, sorghum, and the sugar maple, obtained by evaporating the juice or sap down to a certain consistency, while molasses is a by-product from cane or beet-sugar factories.

The sirup production in the United States has fluctuated with reference to the above sources, and the production is relatively decreasing. The most important factors in regulating the production are the increased output of molasses, the lowering of the price of cane sugar placing home-made sugar sirups within reasonable reach, the increased cost of labor, the exhaustion of maple orchards through clearing, and the great increase in the variety of other sweets prepared for the table.

Louisiana and Texas are the only states that cul-

tivate cane for the commercial production of sugar, but a varying amount is grown in Florida, Mississippi, Alabama, Georgia, Arkansas, and South Carolina for the manufacture of sirup. Practically all of the product is consumed within the states in which it is produced.

Sorghum makes a healthful and palatable sirup, but has never been utilized successfully in the manufacture of sugar. Tennessee, Missouri, Texas, Kentucky, and Kansas produce more than one half of the total sorghum output of the United States, which aggregates about 20,000,000 gallons per year. This sells at forty to fifty cents per gallon on the farms when offered for sale. The cultivation of sorghum increased rapidly from 1860 to 1880, but the decline subsequently has been as conspicuous. The increase following 1860 was due to the high price of sugar during and after the Civil War, and the resultant poverty which reigned throughout the Southern and the Middle Atlantic States.

Sorghum is a plant which thrives best in the temperate zone, but has never been cultivated on a large scale except in parts of China. Most farmers who elect to make it a farm crop cultivate a small acreage which will produce enough sirup to meet the home demand. The average yield is fifty to one hundred gallons per acre,

depending on the fertility of the soil and the cultivation.

Cane sirup is a primary product from cane juice and should commend itself for human consumption, since it not only has a pleasing flavor, but lacks the impurities which appear in concentrated form in molasses. It is unfortunate that there is a general preference for the light-colored sirups and molasses, as these almost without exception are either glucose sirups or a less desirable form of by-product molasses.

For the manufacture of sirup the cane sugar must be converted into invert-sugars, or the sugar will crystallize in the sirup. Crystallization is prevented by leaving the acids in the juice, which on heating assist to convert the cane sugar into invert-sugar. The invert-sugars do not crystallize either on cooling or by agitation. Since the acids are neutralized by the addition of lime, treatment therewith is withheld in the evaporation of cane juice for the manufacture of sirup. Rapid evaporation is necessary for the most efficient separation of the sugar from the sirup, but slow boiling is desired in the manufacture of sirup, since it permits a thicker sirup formation without the crystallization of sugar. Sirups should be evaporated almost to the point of crystallization, as the more viscous it is the less liable it is to ferment. If the

Beaumé hydrometer is used to determine the specific gravity, 34 to 35 is the consistency aimed at for the American varieties of cane.

The sap of maple trees has for centuries been utilized in the manufacture of both sirup and sugar. It still constitutes an industry in the United States and in Central Europe, but is declining with the clearing of the forests and under the severe competition of cheap adulterants and imitations.

The sugar maple in the United States has a wide geographic range, extending from northern New England into the southern part of the Appalachian Mountains, and as far west as Montana. More than eighty-five per cent of the total maple-sugar output is produced by the North Atlantic States, while about the same per cent of the maple-sirup output is produced by the North Central States. The maple-sugar production is now running from 10,000,000 to 12,000,000 pounds per year, and the sirup production about 2,000,000 gallons per year. Vermont and New York produce two thirds of the maple sugar, and Ohio, New York, and Indiana two thirds of the total maple sirup. The maple-sugar industry has steadily declined since 1850, at which time the total annual yield was more than 50,000,000 pounds. The sirup production has not declined so rapidly as in the case of sugar, by

reason of the greater demand for the sirup and the larger profits therefrom.

The manufacture of sugar and sirup from the maple sap is a simple process. The harvest begins

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A Sugar-maple Orchard—Gathering the Sap.

with the first thaws of spring, which start the sap to flowing through the cellular arteries. This is obtained from the tree by boring holes one half to three quarter inch in diameter and one inch deep, into which small funnels or spigots are inserted. The rapidity of the flow depends on the tempera-

ture, the size and age of the tree, and the duration of time since the tree was tapped. Periodically the sap is collected in buckets and carried to the boiling station. Formerly the sap was evaporated in open kettles, but evaporating pans are now used exclusively. It is customary to have two evaporating pans which are communicative through a spigot. The sap is boiled down in part in the upper one, and at regular intervals is conveyed into the lower, in which the reduction is completed. Four gallons of sap produce about one pound of sugar, and an average size tree will run at least twelve gallons of sap in one season. The sugar content varies from 2.75 to 5 per cent.

It is believed that the sap of the maple tree was utilized by the American Indians prior to the discovery of America. The sugar and the sirup represented a prized luxury in the homes of the pioneers. Not only was it used in the household for cooking purposes, but was a standard sweet for the table. It also served an important purpose in the social order, for maple sugar was passed to invited guests just as any modern refreshment or drink is served in a well-appointed home of to-day.

CHAPTER XIII

CANDY, A NATIONAL LUXURY

Candy has steadily maintained its place as a popular luxury since that shrewd Roman baker, Julius Dragatus, made the first sugar plums and offered them for sale on the streets of the world's capital city. This was one hundred and thirty-seven years before the birth of Christ, and throughout the long subsequent period this sugary concoction, so satisfying to the "sweet tooth," has been manufactured in all countries and the demand has steadily increased. Its manufacture and uses have naturally fluctuated in the different countries with the price of sugar, but even when this commodity was commanding almost prohibitory prices for consumption, sugar candies continued to be made, and pushed their way steadily and persistently into the remotest marts of trade. The increase in consumption has been no more striking than the progress achieved in its varied and attractive preparations. Each nation has developed the art

of manufacture in accordance with its own peculiar tastes, which are both cultivated and catered to by its most gifted confectionery artists. So true is this that the purchase of candies in different countries conveys to the foreign purchaser a certain distinct impression of racial characteristics and customs.

The candy habit is one that is not easily changed, and many will forego the pleasure of the sweets unless the kinds for which they have acquired a delectable taste can be obtained. The New York candy importers, therefore, find themselves under the necessity of purchasing candy supplies from the most remote regions of the world to satisfy the demand of emigrants who happen to be from the respective countries. The confectioners' stores carrying imported goods are particularly interesting to the American visitor, who is accustomed to seeing only domestic candies. The odorous atmosphere of the place instinctively leads the visitor to first inspect the different foreign varieties through the discriminating olfactory, and, verily, the Oriental candies have a smell all their own. There are at least four different classes from Asiatic countries carried by the New York importers, and it is altogether probable that some of these varieties represent more nearly the ancient forms than any others existing in the world.

The Chinese have long had the art of making a variety of candies, and they also take particular pleasure in manufacturing it into curious shapes and forms for marketing. One of the most interesting of these is the candy orange and the candy egg, which is nothing more than the orange peel or the egg shell filled with some variety of native candy, but manipulated in such a way that the purchaser cannot find the opening through which the original content was ejected and the sweet injected. To obtain the edible portion, therefore, it is necessary to peel the "orange" or break the "egg."

Few readers realize that the annual candy consumption in the United States costs the enormous sum of $500,000,000. We are not only unrivaled by any other country of the world in the consumption of candy, but consumed more in 1909 than all other countries reporting candy manufacture.

New York City is the largest consuming center in the world both as to total consumption and per capita consumption. In fact, New York consumed one-tenth of the total product, but contains a little less than one-sixteenth of the total population. If all the candy consumed in this city had been shipped in on the railroad, it would have required 12,500 cars to have carried the supply. That is, it would take five trains of candy per week of fifty

cars each to supply the demand. Probably one reason that New York is such a large consumer is because of the large percentage of foreign population, since the foreign emigrant of American cities is by far the largest consumer, while the native poor of the same cities are only second to the emigrant in the extent to which they satisfy this desire. At first thought we would expect the wealthier classes to be the largest consumers of candy, but such is not the case. They are, of course, the largest consumers of the high-priced candies, but there are at least ten pounds of the cheaper grades sold to each pound of the high-priced varieties. There is an economic reason why our poor are the great candy consumers, since their standard of living is so low and the food commodities consumed so inferior that they have an abnormal desire and relish for even the cheaper sweets. Not only does candy appeal to the taste, but it is a nutritious food and serves the added purpose of satisfying the appetite of the consumer, which in the case of the poorest classes is always seeking satisfaction.

The consumption of candy has increased more rapidly in this country than the consumption of sugar, and yet we are individually the largest consumers of sugar in the world. Statistically, Great Britain's per capita sugar bill exceeds ours, but the latter country is a very large exporter of pre-

serves, jams, jellies, canned fruits, and candies, while the United States exports comparatively little of these commodities. Making allowance for this part of the United Kingdom's sugar consumption, which, though accredited to the country, is not consumed by the countrymen, leaves the United States without a peer in the sugar- and candy-eating rôle.

CHAPTER XIV

BY-PRODUCTS

The corresponding by-products from the various stages in the production of sugar from sugar beets and sugar cane are quite similar both as to character and uses. The important by-products from beets are tops, crowns, pulp, molasses, and press-cake; and from cane, tops, bagasse, molasses, and press-cake.

The tops and crowns average four tons per acre, and have been utilized only as stock food and fertilizer, the average value for the former purpose being from $1 to $2 per ton, depending upon the locality. Since the mineral constituents contained, potash, soda, lime, magnesia, chlorine, sulphuric acid, and phosphoric acid, are important plant foods, these by-products become valuable as fertilizers when applied to the soil. If they are plowed under the fertilizer property is increased by the addition of humus, which accrues from the decomposition of the vegetable matter.

The pulp from the beet factory is the residual part of the spent cossettes after the sugar content has been reduced to a minimum by the continuous contact of warm water. These contain, however, from 0.25 to 0.50 per cent of sugar, 1.5 to 3.5 per cent cellulose, 90 per cent water, and a small percentage of mineral matter. This by-product from the sugar-beet factories has not been handled in the past economically, since it was considered by many factory owners as neither worth the handling nor preserving. Much progress is being made at this time in turning it to profit as a stock food. The pulp is either transferred to large silos for winter feeding, piled green in bulk in the field, or more or less dried for mixing and shipment. The best results seem to have been obtained by partially drying it and mixing it with such feeds as molasses, oil cake, ground grain, or chopped hay. In Germany more than one half of the total pulp output is dried for use in the manufacture of mixed stock feeds. In the artificial drying the amount of water is reduced to about ten or twelve per cent, which represents the average content of water or moisture in hay. The product at this stage resembles closely in appearance green tea. The drying is for the purpose of decreasing the weight and bulk, and to prevent the deterioration of the product from fermentation.

Feeds in which the dry pulp constitutes a basal part are highly recommended for their feeding value, especially for dairy cows and horses. If it is balanced with either molasses or ground grain the quality of milk produced by it is superior to that which results from a mixed grain and hay ration.

In factories equipped for utilizing the pulp profitably it is estimated in value at one-fifth the original cost of the beets, which at the present price would make it $1 to $1.25 per ton.

The Germans utilize beet pulp to a limited extent in the manufacture of paper, and a syndicate has been organized in Colorado for beginning the manufacture in this country.

The tops from the cane are even more valuable as a stock food than the tops from the beet, the average estimated value being $5 per ton. These have been utilized in the Southern States economically, as there is always a scarcity of forage crops suited to feeding the domestic animals required on the various plantations.

The woody pulp left after the extraction of the juice from the cane is called bagasse. It contains four to six per cent of sugar when the most improved methods of sugar extraction are utilized. It also contains certain mineral matters in addition to the organic matter, and a consider-

able quantity of water. No other by-product of the sugar factory has proven so intractible to utilization. Being of great bulk, it becomes a difficult problem to transport it or to find room for storage around the factory. It has had a limited use as a fertilizer by scattering it back on the land, but the benefits scarcely balance the cost of handling. It is also dangerous to leave it in large masses, as the fermentation may generate sufficient heat to produce a conflagration. It has been used to a limited extent as a stock food by mixing with molasses, the mixture being called *molascuit*. Although it contains elements of animal nutrition, they are intermixed with indigestible fiber and mineral matter unassimilable, making the profit of this utilization questionable.

The use of bagasse as a fuel seems to represent the most satisfactory solution of the problem, notwithstanding the fact no furnace has yet been invented for that economic consumption which is desired. Fuel is very expensive in most of the cane-growing countries of the world, and since in a furnace adapted to drying and burning the bagasse it will supply forty per cent of the motive power necessary in the factory, the perfecting of a bagasse-burning furnace would materially lower the cost of factory production.

Another possibility which has been contemplated

with hope is the conversion of the bagasse into paper. This, however, is not a success under any method which has been recommended or tested, and it seems doubtful whether science will be able to overcome the physical and chemical handicaps in the way of separating the fiber from its associated elements.

MOLASSES

Molasses is the residual product from sugar manufacture after separating all sugar which can be economically crystallized by evaporation. It contains fifty to sixty per cent of water, thirteen per cent of non-nitrogenous matter, and a varying small percentage of mineral matter. The molasses from sugar cane contains at least ten per cent more sugar than that from beets. The impurities give to molasses from cane and beets an objectionable taste, making it unpopular as a table food. So limited was the demand, even at low prices, that millions of gallons were discarded in the cane-growing countries before profitable uses of low-grade molasses were discovered.

The manufacture of rum was one of the first appropriative uses of cane molasses. Under the old "open-kettle" method of reduction about six per cent of the cane juice was contained in the scums, and lost unless utilized in the manufacture of rum.

The profit from rum depended largely on the locality, as some soils produced an article of great superiority over that from other cane-growing regions. The Jamaica rum has long been noted for its fine flavor, and has not been successfully duplicated in any other country. The rum production has declined in the United States in favor of cheaper molasses-producing countries and in favor of the more profitable commodity, alcohol. In 1907, only 2,483,022 gallons of molasses were so used. The utilization of molasses from beet-sugar factories for the manufacture of alcohol is increasing steadily. More than 20,000,000 gallons of molasses were converted into 10,000,000 gallons of alcohol in 1907. While it takes two and one half gallons of molasses from beets to produce one gallon of ninety-five per cent alcohol, only two gallons of cane molasses are required because of the higher sugar content of the latter. Michigan is the only state which utilizes the whole of its molasses output in the manufacture of alcohol, and stands first in total production, with New York second, and Louisiana third. Practically all of the residuary molasses are converted into alcohol by fermentation; the chemical salts remain as a residue, and are either sold to the fertilizer manufacturers or refined for the separation and purification of the potash salts, in demand for the manufacture of glass.

Molasses has been extensively used in Egypt as a fuel, the cost of which is so high in that country as to make this an economic utilization. The furnace must be of a special type for molasses consumption. First it is reduced to a charry carbon form, and this is completely consumed in combustion. As a fuel molasses is an efficient generator of steam power, but the rapidly increasing demand will soon command for it a value prohibitive of this application.

In Java molasses is applied to the soil as a fertilizer, thereby returning most of the plant nutrition taken from it. We naturally think of this as being an expensive method of maintaining fertility, but in that country the by-product sells as low as three cents per gallon, which is about one-fourth cent per pound. The chemists having the experiments in charge claim that the most satisfactory results are obtained by mixing the molasses with furnace ash, filter-press mud, and dried manure.

Molasses as a stock food has grown in favor since 1885, when England began to import "black strap" for this purpose. Very little was fed in the United States until fifteen years later, but now it is one of the standard mixed stock foods on the American market. In the cane-growing states of the South, it is both fed from open tanks and

mixed with other feeds, grain, and forage. The mixed feeds are prepared in general in four ways: By mixing molasses with a primary product, such as grain or chopped hay, without subjecting any of the materials to heat; by mixing hot molasses with cold primary products; by mixing cold molasses with kiln-dried primary products; and the mixing of hot molasses with artificially dried products. The last method gives the most satisfactory results in preventing fermentation, which represents the most serious danger and handicap in the storage and feeding of molasses in mixed feeds. The most common products for the preparation of these standard feeds are cottonseed meal, dried brewers' grain, rice bran, rice hulls, corn, ground cobs, wheat screenings, oats, dried beet pulp, and ground or chopped hay and straw. The molasses mixtures are in greatest demand for feeding horses and dairy cows. The supply is inadequate to the demand in the United States, as a result of which the price has steadily increased, the average being $20 per ton, or more than ten cents per gallon. Since molasses contains about the same amount of carbohydrates as corn, it is cheaper at the above high price than corn at present market prices. As a food, it is not only a generator of heat, but a builder of muscular tissue, and possesses the combined properties of stimulating the appetite, in-

creasing the secretion of digestive juices, and increasing the saliva supply.

The lime cake from the factory filter presses is a valuable fertilizer, since it contains about 87 per cent of calcium carbonate, 10 per cent organic matter, 1.5 per cent of phosphoric acid, and small quantities of potash and nitrogen. These are essential fertilizing ingredients for all crops. The application of this by-product to beet-growing soils increases the tonnage yield and the sugar content, prevents rapid evaporation of the soil moisture, and prevents certain diseases which are frequently destructive.

CHAPTER XV

FROM REFINER TO CONSUMER

The discussion thus far has dealt primarily with the economic side of production. The agencies and channels of sugar distribution are more clearly differentiated from the sources of supply than for any other commodity which can be listed as a staple food. This condition has for centuries characterized the sugar industry, the economic explanation of which is that cane sugar, being a tropical product, was remote from the regions of densest population and largest market centers. The climatic and economic conditions of these tropical belts made entirely impracticable the manufacture of the finished product in the cane-growing regions.

During our colonial period the world's sugar supply was controlled by the stronger commercial countries of Europe, of which Great Britain was head. The supply, therefore, for the American colonies came largely at this time through the London brokers, even when shipped direct from the

West Indies. Granulated sugar was then more of a curiosity than daily luxury, and the domestic supply consisted almost exclusively of soft sugars, which varied in color from dark brown to a light straw yellow.

The first sugar refinery in the United States of which we have record was established on Liberty Street, New York, in 1689. This was of small capacity and only produced soft sugars. The refining industry did not develop to the extent of attaining industrial importance until the middle of the succeeding century, at which time small refineries were in operation in New York, Boston, and Philadelphia. By the close of the seventeenth century Philadelphia had become the largest refining center in the United States, while Boston was developing the industry with greatest rapidity, having established in the last decade of the century seven new refineries. Even at this time less than two per cent of the total sugar consumed in the United States was refined. The indications are that practically all of the refiners realized an encouraging profit on the business, and the competition, instead of being strong between the independent refiners, was strong between the London exporters of raw sugar and the American refiners.

The dawn of the nineteenth century brought with it important political activities in Europe

and small industrial plants in America, which held within them the potency for ultimately revolutionizing the sugar industry. The French Revolution paralyzed the European sugar trade, as evidenced by the fact that it commanded a price of one to two dollars per pound in 1811, following the blockade of the continental ports of Europe. Six years previous to this two German emigrants by the name of Frederick and William Havemeyer had started a small sugar-refining business in the village of Greenwich, which spot has long been a part of the City of New York. They came to the United States equipped with valuable experience in the methods of sugar refining in vogue in Germany, and a small amount of money. From the beginning they were aggressive and alert, and rapidly gained influence in the sugar refining business of the east. The refining business just at this time was greatly stimulated by the Federal Government. In 1812, when England's sugar interests were suffering severely both from the pressure of the Revolution and the blocking of continental trade, the United States raised the duty on refined sugar from nine cents to eighteen cents per pound, the duty on raw sugar being only three cents per pound. This tariff was prohibitory, and gave the American refiners a monopoly on refined sugar. The duty was not placed below ten cents

per pound until 1842, nor was the duty on raw sugar raised above three cents per pound. The refiners had the additional advantage from 1816 to 1842 of a refundment on all refined sugar exported in excess of the duty on raw sugar. They, therefore, had the power of not only fixing the domestic price, but of reaping large profits on the export trade through the legislative concessions. Naturally, the refiners realized such large profits that the domestic competitive conditions became more alluring and intense each year. The Havemeyers had already become the strongest individual firm in the competitive field and were trying out on a relatively small scale those policies and schemes which were destined to be launched later on a gigantic scale.

From 1840 to 1860 the sugar industry in Louisiana prospered, and most of this product was sold in the lower Mississippi Valley in an unrefined condition. Louisiana sugar thereby became a competitive factor and had an appreciable influence on the market. The Civil War, however, not only depressed the Louisiana sugar production, but almost annihilated it, and the removal of domestic competition gave back to the refiners almost unlimited price-fixing power. Following the war, prices on all food commodities soared high, as a result of which the impoverished

Southern States almost ceased to purchase refined sugar. This placed the refiner at the necessity of seeking his profits from exports.

The Pacific Coast was still a frontier country, but thousands were being added to the population each year. Just at the time when the Gulf Coast competition was being eliminated by the accident of war, Claus Spreckels began refining on a small scale in San Francisco. He was remote from the eastern competition and could obtain his raw sugar from Hawaii. His geographic situation enabled him to practically supply the Pacific Coast at his own price, which is equivalent to saying that the Spreckels business prospered. The heydey of the Spreckels prosperity did not appear until 1875, when the United States established reciprocity relations with Hawaii, admitting sugar free. Economically, this meant the lowering of the cost of sugar to the consumer, but the facts are that the Spreckels refineries used their enlarged power in raising the price of the commodity. How completely this power was exercised is attested by the price of Spreckels's sugar in San Francisco being higher than the price of Spreckels's sugar in Kansas City. No flight of the imagination is necessary for believing that this daring western German was having focused on him across the Rocky Mountains several pairs of cold, undaunted German eyes from

the Great Metropolis. By 1880 the competition assumed a triangular defensive between the eastern refiners, the Pacific Coast refiners, and the Gulf Coast brown-sugar makers. This competition naturally brought about rate wars, which immediately opened the firing line within the ranks of the eastern refiners, the more important of whom were operating in New York, Philadelphia, Boston, and Baltimore. The ferocity of the combat may be inferred from the failure of more than one third of the refiners of these cities in less than one decade. It is needless to say that the competitive conditions waged most vigorously were initiated, followed up, and consummated by the strongest of those who survived. The Havemeyer firm was recognized now as the most daring and the most dictatorial. That their methods were at least of a questionable character is amply signalized by the different governmental investigations on behalf of the United States and the discriminated independents.

The financial storm in the circle of sugar refiners was followed by the pooling agreement of 1887, which, in its origin, organization, and character, represented the birth of the Sugar Trust. The lines of control tightened with magic swiftness. The personnel of the small absorbed independents was lost in the undercurrent of reorganization, and

the capitalization increased from seven million to fifty million dollars through the simple process of stock watering. The price of sugar rose immediately twenty per cent and continued to rise during two years. The refiners' differential was increased from three-fourths cents per pound to one and one-fourth cents per pound. So enormous were the profits that ten per cent dividends were regularly declared on the new capitalization.

In 1889 the wholesale grocers of the United States became a party to the Trust manipulations by forming a national organization and agreeing to sell sugar on a fixed margin of one-fourth cent per pound. This organization, known as the Wholesale Grocers, entered into a definite agreement with the Sugar Trust in 1891, by which the latter was given the power to fix the price in the different zones named. To make the control absolute the Trust granted a rebate of one-eighth cent per pound to the wholesaler at the end of each quarter, provided he had not been an offender.

The financial depression, which began in 1890 and reached its zenith in 1893, and the aggressive competition of the independents steadily forced the price of sugar down until it reached the low retail water-mark of 4.12 cents per pound in 1894. Claus Spreckels, Sr., kept up his heroic fight in the

east until 1892, at which time he yielded to the pressure and overtures of the Trust. Be it said to the honor of his son, Claus A. Spreckels, manager of the Spreckels' refinery in Philadelphia, that he refused to sell or to consolidate, which not only placed him on the firing line against the Trust, but caused a rupture in the Spreckels family which has not been healed.

From 1894 to 1899 numerous independents sprang up, notwithstanding the fact that the Trust controlled more than eighty per cent of the total output. These were sufficiently strong to cut down the refiners' differential, and to wage a competitive warfare which was at least uncomfortable to the more powerful opponents. The strongest of the independents of this period were Mollenhauer, of Brooklyn; Howells, of Yonkers; McCahan, of Philadelphia; Arbuckle Brothers, of New York; and Claus Doscher, of New York. In 1900, Mollenhauer, Howells, and Doscher interests consolidated into the National Refining Company of New Jersey, which immediately was brought into harmony with the Trust. This left the Arbuckle Brothers, McCahan Sugar Refining Company, and the Pennsylvania Sugar Refining Company the only large independents, with a capacity of 10,500 barrels per day.

Prior to 1900 the Sugar Trust gave little atten-

tion to the beet-sugar industry in the west. In this year, however, a rate war was begun by the Trust (American Refining Company) by quoting sugar at three and one-half cents per pound at points along the Missouri River, this being below the market price of raw sugar at that time. Subsequently the Trust has steadily increased its activities in the acquirement of beet-sugar properties both by purchase and by the development of community interests, until now it controls probably more than fifty per cent of the total beet-sugar production.

It is not our purpose to elaborate on the merits or demerits of Trust control, nor to argue the question whether the Sugar Trust, under the corporate name of the American Refining Company, is supplying sugar at a less cost to the consumer than would have been possible without its organization, but it must be admitted in just recognition of the facts that the methods resorted to in its organization, importation of raw product, and distribution of refined product constitute a dark and disreputable page in the history of American industrialism. Its sins were sufficiently contemptible to inspire an adverse public opinion, to command a series of investigations by the United States Government, and to set family against family even within the corporate house.

CONTROL OF SUPPLY

The refiners can only partially control the total production of raw sugar in any country which must import the bulk of the sugar consumed, but they almost absolutely control the supply to the consumer. The United States is obviously in this class, since four-fifths of the sugar consumed is imported from outlying territory and foreign countries.

The supply of sugar which is accessible to the refiners of the United States fluctuates with the production of the cane-growing countries nearest to us, and with the strength of the demand in more remote sugar-importing countries. Almost one-half of the total sugar imported by the United States at this time comes from Cuba, and the United States refiner holds the power of practically controlling the Cuban output by reason of the preferential tariff and the smaller transportation cost. Should the demand in London be such that the London broker could afford to pay the Cuban producer more than the price offered by the refiners of the United States, the Cuban supply would either go to London or the Cuban producer would receive a higher price for his sugar from the refiners of the United States.

The beet-growing countries of Europe had an

important influence on the American supply of sugar prior to the Brussells' Convention of 1902, which effected a readjustment of the domestic tax and the export drawback in the European countries. The agreement of this Convention also had the effect of terminating the combination agreement which had long existed between the producers of raw beet sugar and the refiners. As a result, the price of raw beet sugar rose to a standard which was practically prohibitory to competition with the cane-producing countries. The effect was marked on the sugar supply and the sugar trade of the United States. From 1896 to 1902 the importation of beet sugar from Europe averaged 371,318 tons, while in 1908 it was less than 2,000 tons.

CONTROL OF PRICE

Of the multitude of elements which directly or indirectly are influential in the control of prices, we shall only enumerate the more significant. It is usually granted that when a distributing agent can control the output it will be able to fix the price, and this has been one of the impelling methods used by the sugar refiners of the United States since the beginning of corporation control. If we consider the world's sugar supply with reference to a world market, then it must be granted that

Germany is the most influential factor in fixing a world price. There are many conditions, however, which prevent the economic conditions in vogue in Germany from fixing the price of sugar in America, excepting within very large limits. The reader has already suggested to himself the tariff protection as being the most effectual barrier in safeguarding the domestic price.

Probably the next most important element in the control of the price on raw sugars is the transportation cost from the various countries which produce a surplus. The refiners use this margin to the limit in purchasing the product at an advantageous rate. It is also used as an argumentative pressure in many cases; to illustrate, the eastern refiner purchases raw sugar in Louisiana at the New York market price less the transportation charge from Louisiana to New York, and after obtaining this concession refines most of the product in New Orleans.

Naturally the volume of the purchase has much to do with the fixing of the price. A large purchaser can always obtain his goods at a lower price, and on account of the difficulty of storing raw sugar without deterioration, it is emphatically true of this commodity. This, therefore, represents one of the economies which has been accentuated by the consolidation of the refiners.

The time at which the purchase is made is probably more influential in controlling the price than the volume of the purchase. The Louisiana sugars go on the market from December to May, and toward the latter part of this period the Cuban sugars are also seeking purchasers. Both producers are dependent largely on the eastern refiners for the purchase of the product, and these in turn manipulate the market, playing both ends against the center for the lowering of the price. This also happens to be the season when the rate of consumption in the United States is least, and as a business proposition the refiners lower the price on the refined product to increase the sales. This arbitrary lowering of the price on the refined product is then used with powerful pressure to lower the price on the purchases of raw sugar.

The price of sugar under Trust control has fluctuated, but the average price has been lower than previous to 1890, notwithstanding the fact that the average differential to the refiner has been considerably higher. It is also true that the retail price of sugar in the United States is lower than in any other large sugar-consuming country except Great Britain. The price is steadily maintained with reference to the largest perpetual profit. The introduction of large scale production gave increasing returns of profit through economies of

operation, labor-saving inventions, improved methods of transportation and distribution, all of which may be classed as legitimate economies and improvements. That there were also questionable policies practiced, we have already hinted at, and for further evidence the public must await further investigations.

CHAPTER XVI

OUR FUTURE SUGAR SUPPLY

It is safe to predict that the people of the United States will become heavier consumers of sugar unless the price of sugar should increase disproportionately to other foods; and in any event the future supply must be much larger than the present consumption. Whether the development of the sugar industry of the world can keep economic pace with the increase in population is an interesting and important problem; but whether the United States can meet her demand, and how, is a question of more immediate and vital importance to the current discussion.

We believe that the signs of the times point to the sugar industry becoming more and more of a world industry with reference to production, and that at the same time it will become more concentrated in certain regions whose natural adaptation gives sugar-producing plants the vantage over other merchantable crops. The rivalry between

sugar cane, and tobacco, rice, cotton, coffee, vegetables, and fruits must become keener, and as a result more economically differentiated. The regions adapted to the sugar beet are situated in the zone which must continue to supply the world with most of the breadstuffs, meats, and meat products. The demand for these will increase commensurate with the population increase, making it necessary for the beet acreage to hold its place against rivals of increasing strength. In the last analysis the grain crops will continue to stand firm against all rivals up to the point of supplying the peoples of the temperate zone with an adequate bread supply, and the indications are convincing that the demand of the tropics for temperate-zone grains will also increase persistently. Under the present system of production the world's meat, butter, and milk supply is largely dependent on the grain production, and under normal-price conditions these stand next to breadstuffs on the diet scale in urgency of demand and desire, and so will become more formidable rivals as the population of the great grain-producing countries increases.

It is obvious, therefore, that the sugar-beet and sugar-cane zones will be squeezed from without and within with a pressure which will result in concentration in parts of the zone and decentralization in others. Differentiation of this character

is apparent in the United States at this time. Some land in the Mississippi delta is so profitably adapted to cane that it commands a market price of $200 to $300 per acre, and is being used more intensively each year. In the more inland part of the coastal plain the cane acreage is being slowly extended; slowly, because experimentally.

Just at the time when the promoters of the sugar-beet industry felt that its security as the chief money crop in the irrigated regions of the west was fixed, luring reports became rife as to realized profits on apples, peaches, and small fruits in Colorado, Idaho, Oregon, and New Mexico. About the same time the small farmers and gardeners showed an equally attractive report of the net annual acreage income from potatoes, onions, and cantaloupes. A new adjustment had to be established. Not that the beet-sugar factories of Idaho, in which the shuffle is most vigorous, were unprofitable, but that an income of $40 to $60 per acre became unsatisfactory under a favorable prospect of receiving an annual income of $200 to $500 per acre by waiting six or eight years for the working capital to make its start. The planting of old beet fields in apple trees and strawberries is but the outward sign of the revolution and evolution in progress. Other states, like Michigan, Nebraska, and Kansas, which had

grown beets and manufactured them on a small scale, but somewhat half-heartedly, took heart and began to strike the anvil of their opportunity with vigor and purpose. The general result is that the total acreage has been rapidly extended and factory construction and operation placed on a more permanent and economic basis.

The beet zone of the United States is not so circumscribed by geographic limitations as the sugar-cane zone, and is more centrally located with reference to the largest number of consumers. The beet-sugar industry is also developing along more independent lines, in that the manufacturing process is complete from the beet to refined sugar ready for distribution. Weighing all of the evidence the sugar-beet industry gives prospect of developing more rapidly and to a much larger maximum production than the domestic cane industry. The expansion limit for economic development will be fixed by so many factors that the future growth of either branch of the industry is problematical, so that the most responsible conclusions which can be reached are deducible from a series of economic and commercial possibilities.

We have already seen that the cane zone could be extended about ten-fold, and that the beet zone is capable of even larger extension.

Under present conditions of production it is dif-

ficult to see how the sugar industry of this country could meet the competitive conditions of a removal or a marked reduction of the tariff on sugar, unless that would bring with it an increase in the price of raw and refined sugar in the price-fixing markets of the world. Cuba is admittedly our most dangerous competitor now in reducing the price of raw sugar to a close margin of profit for the cane grower, but the handicaps of inefficient and inadequate labor hang even more ominously over Cuba than the United States. The United States receives now under the preferential tariff about nineteen-twentieths of the total crop, which is more than three times the amount received from the island in 1901. This shows the urgency of our increasing demand. The Cuban planters report that they are maintaining the present large production under the most serious difficulties; so, is it not as probable that even a reduction or removal of the tariff on Cuban sugar would be an opportunity for the Cuban growers and manufacturers to raise the price on raw sugar? Our opinion is that a tariff reduction on raw sugar would slightly lower the price of raw sugar, increase the refiners' differential, and increase the price of raw sugar in the tropical exporting countries.

The field cost of producing both beets and cane seems to be increasing throughout the sugar-pro-

ducing regions, but the economies in methods of manufacture which have been invented and introduced have thus far more than counterbalanced the increased cost of field production. We cannot foretell the readjustments of the future in the different countries concerned as to cost of labor, cost of machinery, and aggregate cost of manufacture. The economic conditions, however, point to a continued increase of producing costs in the tropical regions for some time to come. It is also true that there are various elements operating throughout the industrial countries of the temperate zone, which are likely to place a limit on further economies in factory equipment; chiefly because the cost of iron, steel, and lumber products is increasing throughout the world with the increased consumption and the proportionate exhaustion of the raw supplies out of which these products are manufactured.

In considering the future production and consumption of sugar we should take into account the probable exploitation of the sugar-cane industry in South America, tropical Africa, and southern Asia, and the beet-sugar industry in northern Asia. Unless there is a rapid development of the domestic sugar industry in South American countries, the countries of this continent must become heavy importers. Since the industry

is growing at this time proportionate to the increased demand it seems reasonable to conclude that the South American continent will at least continue to supply the domestic demand. Should the world price of sugar increase and the tariff conditions be made favorable it is not at all impossible that a part of the United States' future sugar demand may be supplied by our South American neighbors.

The general industrial exploitation which is certain to take place in Africa will create a continuous and growing demand for sugar in that continent. It is significant to note that the production at this time is not increasing proportionate to the consumption, and a general survey of the geographic conditions of that continent would indicate that Africa is more likely to be an importer of sugar than an exporter. The densely populated countries of the southern half of Asia are increasing their production annually, but here the rate of production increase is not keeping pace with the increase in consumption. Even China is purchasing more sugar than at any time in the past.

It is only a question of time when the beet-sugar industry will be successfully exploited in parts of Siberia, and in certain regions of western Asia which are susceptible to irrigation. In any survey of the present and future beet-growing countries

both European and Asiatic Russia must be counted as regions which in geographic and soil environment hold out the most favorable prospect for development on a large scale. The industry is recognized now by the Russian Government as one of her substantial agricultural resources, and with the extension of the industry in area has come an improvement in method of cultivation and manufacture which is encouraging to the sugar purchasers of Europe, and alarming to the beet-growing countries. It is indeed fortunate for the world industry that this part of the northern hemisphere has so large a zone economically adapted to the profitable cultivation of beets. The older beet-producing countries of Europe, of which Germany has been most conspicuous, are regions of dense population, which makes the competitive struggle more severe, and of necessity places any one industry under restrictions as to its extension.

When we compare the present status of the producing and consuming countries with the most natural economic development of the future we are forced to the conclusion that the United States will have to depend largely on the islands of the Pacific and the Atlantic for our imported sugar supply. Of all of these, the Philippines probably offer the opportunity for the most favorable and rapid increase in total production. A correlated

consideration of these more or less speculative arguments leads us to believe that the future demand for sugar will increase disproportionate to the profitable exploitation of the industry on the basis of present price, which would lead to a rise rather than a decline in the price of sugar; and furthermore, that the conditions and character of the imported supply will continue to be favorable to the domestic development of both our cane and beet-sugar industries.

We have, thus far, taken no account of the possible or probable changes in the demand for cane and beet sugar through the utilization of other sugar-producing plants. The results of experiments thus far perfected do not indicate that any great evolution in the world's industry is likely to take place through the development of more economic sugar-producing plants. The scientists and inventors have long hoped to discover or develop a successful method for the reduction and crystallization of sugar from the juice of sorghum. Even if this should be accomplished it would only have the result of extending the cane zone into the temperate region, in most of which the profits on sugar from sorghum would probably not be more than could be realized from the cultivation of sugar beets in the same region. We have previously mentioned the results of experiments in the separation

of sugar from Indian corn at certain stages of its growth. The increasing demand for all the fruits indigenous to the tropical and the temperate zones would suggest the improbability of fruits being used more in the future as a source of sugar than they have been in the past.

We are scarcely justified in making a surmise as to what the future holds in store in the way of sugar substitutes. No successful substitute for crystallized sugar has as yet been placed on the market, but the success of sirup manufacture from glucose has been so significant as to make us wonder what cheap, stable, and convenient substitutes for sugar may be awaiting the hand that can set them free.

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